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Journal

—OF THE—

American Ceramic Society

A Monthly Journal devoted to the Arts and Sciences Related to the Silicate Industries

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JOURNAL
OF THE
AMERICAN CERAMIC SOCIETY

A monthly journal devoted to the arts and sciences related to the silicate industries.

Vol. 3 **September, 1920** **No. 9**

EDITORIAL

TEN WAYS TO KILL AN ASSOCIATION

The following interesting bit of satire, entitled "Ten Ways to Kill an Association," is reproduced from the *Builders' Bulletin* of Wisconsin. It is commended to the consideration of the members of the American Ceramic Society. The ten ways are as follows:

1. Don't come to the meetings.
2. But if you do come, come late.
3. If the weather doesn't suit you, don't think of coming.
4. If you do attend a meeting, find fault with the work of the officers and other members.
5. Never accept an office, as it is easier to criticize than to do things.
6. Nevertheless, get sore if you are not appointed on a committee; but if you are, do not attend the committee meetings.
7. If asked by the chairman to give your opinion regarding some important matter, tell him you have nothing to say. After the meeting tell every one how things ought to be done.
8. Do nothing more than is absolutely necessary, but when other members roll up their sleeves and willingly, unselfishly use their ability to help matters along, howl that the association is run by a clique.
9. Hold back your dues as long as possible, or don't pay at all.
10. Don't bother about getting new members. "Let George do it."

THE FUNCTION OF AN EDITORIAL

Opinion as to what is the proper function of an editorial probably varies with every reader. A few people hold that it is to disseminate information. Some believe that the purpose is to expreses the opinion of the majority of the subscribers to the publication in which the editorial appears; others that the editorial is intended to influence the readers to think as the author of the editorial thinks. Still others look upon the editorial column of their favorite journal as a place in which they can obtain their opinions and ideas ready-made without undergoing the mental effort of forming opinions for themselves.

Our own particular idea of the function of an editorial is that it is intended solely to make people think. From this view point it does not matter whether the views expressed in an editorial agree with those of the majority of the readers; it is of no importance whether the editorial contains information of value or not; and it is even immaterial whether the opinions and facts given in an editorial are correct or wrong. If the editorial acts as a spur to the intellect of the readers and makes them think, it has performed its function. The editorials published in this volume of the JOURNAL have been written for the purpose of stimulating thought on questions of importance to the Society *stimulating thought on questions of importance to the Society and the ceramic industries*, and the opinions expressed therein are in no sense to be taken as expressing the views of the Society on the subjects discussed.

ORIGINAL PAPERS AND DISCUSSIONS

THE CONTINUOUS TUNNEL KILN[1]

By Carl B. Harrop

It is an indisputable fact that the ceramic industry has been for many years and is still wasting more fuel than any other single industry. It is true that there have been sporadic attempts to bring into use more economical firing equipment and methods, but the great majority of manufacturers are still using kilns and methods of the same general character as were used many years ago.

The metallurgical industries and particularly the steel industry have given much consideration to this problem of fuel economy and have developed various kinds of regenerators and recuperators, which together with a minimizing of furnace radiation by the use of heat insulating materials, have resulted in not only a large saving to themselves but also a conservation of our natural fuel resources.

The clayworking industry is one of the largest in the country. Of all the steps in the manufacture of clay wares, including winning the raw materials, preparing the clay, forming the ware, drying the ware and firing the ware, the last named (except possibly in some very unusual cases) involves the largest cost of any single step. Furthermore, the principal cost factor in this step is the fuel, so it seems only reasonable that if we would lower the cost of production, the firing operation offers the best opportunity.

In the ordinary periodic kiln, the principal heat losses occur (*a*) through radiation from the surface of the kiln, (*b*) in the flue gases and (*c*) in the ware and kiln structure at the end of the firing period.

[1] Received February 27, 1920.

In many instances the last named loss is reduced to some extent by drawing air through the cooling kiln and using this heated air for drying the ware. Numerous attempts have been made in various ways to reduce the first two losses, but no methods have yet been generally adopted to greatly reduce them.

There is evident a very sincere and widespread interest in the recent rapid development of the car tunnel type of continuous kiln. There are several arguments in its favor, namely:

(*a*) *Uniformity of firing conditions.* In firing periodic kilns, the time-temperature curve will depend upon the fireman, the condition of the kiln, the setting in the kiln, the fuel, the weather and perhaps some other influences. In the tunnel kiln, it is necessary only to hold a certain fixed temperature, while the rate at which the ware is heated is controlled mechanically, and is dependent upon the rate at which the cars are charged.

(*b*) *Economy of fuel.* The combustion gases can be cooled to practically any degree (dependent upon the length of the kiln) before being discharged into the atmosphere. The fired ware, moving slowly toward the discharge end, gives up its heat to incoming secondary air for combustion and can be cooled to practically any temperature (again dependent upon kiln length). A saving in fuel of from 65 per cent to 75 per cent over periodic kiln operation can be figured on.

(*c*) *Economy of labor.* All placing of ware is done at one general location, as is also the unloading of the cars. The firing of all fuel is centralized. Cleanliness and order are far easier than with other types of kilns.

(*d*) *Construction cost lower than for moving-fire-zone continuous kilns of equal capacity.* The heaviest construction and greatest heat insulation is provided at the high temperature zone—less insulation and lighter construction towards the ends. Every feature and part of the structure is in use at all times. In the chamber continuous kiln, for instance, all chambers must be equipped with full flue systems and other equipment, which are not fully made use of during more than half the time, and, furthermore, all parts of this kiln must be heavily constructed and well insulated.

(*e*) *Lower cost of maintenance.* Expansion and contraction,

due to the periodic heating and cooling of periodic kilns as well as continuous kilns with moving fire zone, results in considerable damage to the masonry. In the continuous tunnel kiln the structure expands when being brought up to heat and contraction takes place only when it becomes necessary to close down the kiln.

In periodic kiln firing a large mass of ware is heated by furnaces located around the outside of the mass. In order to reduce the firing time as much as possible, the temperatures carried in the furnaces are necessarily exceedingly high. This results in severe punishment to the furnace linings and bags. In the case of the tunnel kilns, a relatively small mass of ware gradually approaches the high fire zone. It is possible to have far greater furnace power per unit mass of ware, with the result that it is not necessary to have a furnace temperature, which is as much in excess of the desired ware temperature as is the case with periodic kilns. The advantage is evident.

The purpose of any kiln is to generate heat from the fuel provided and to enable an efficient and prompt transfer of this heat to the ware being fired. Also, it is equally important that all the ware being fired shall be subjected to practically the same degree of heat, so as to secure uniformity of the fired product. There is still a third requirement, which cannot be given too much consideration, namely, capacity of the kiln. Several of the tunnel kilns now being advocated are able to fire ware uniformly, if the ware passes through them slowly; but when the rate of passage of ware is increased, and particularly if the ware is massive, uniformity of quality is greatly reduced.

For firing of certain products, such as sanitary ware set open, terra cotta, and so forth, the muffle tunnel kiln, without question, most nearly meets the requirements. However, for all saggered wares and for most crude structural wares, it would seem that the open- or direct-fired tunnel kiln is the most practical. It is essential that this latter kiln (which embodies the horizontal draft principle of firing) shall be properly designed; the heat applied at the proper elevation and in the proper way, and that the designer have a thorough knowledge of combustion and its control in connection with the ware being fired in each particular instance. Under

the above conditions, there is hardly a doubt that, for a given degree of uniformity of quality, the direct-fired kiln is capable of a greater capacity than the muffle type. However, regardless of comparisons between the two types, the important point which should be thoroughly investigated by all prospective builders of tunnel kilns, is whether or not, with an assured *quality* of product, the daily *capacity* will warrant the cost of the installation.

The tunnel kiln, properly designed and carefully built, is undoubtedly destined to become a thing of great economic importance to the clay-working industry of the country and is sure to supercede the antiquated methods still being clung to by most manufacturers.

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NOTICE—*Discussion of this paper will be published later as part of the Discussion on Tunnel Kilns.*

THE TUNNEL KILN APPLIED TO CERAMICS[1]

By Samuel Trood

There are three principal items to consider in firing tunnel kilns: (1) Heat generation, (2) heat distribution, (3) heat absorption.

Heat generation requires a proper combustible, proper oxidizing agent, proper temperature and in the proper proportion, and a proper mixture of the above. There are two factors in the generation of heat, which are very often misunderstood, *viz.*, the quantity of heat and the intensity of heat.

It is a well known fact that some operations require a higher temperature than others, but this must not be confused with the fact that some operations require a greater amount of heat at certain temperatures. (Example—water.)

The intensity of the heat determines the time element of an operation. It is a matter of laboratory record that heat conductivity, radiation, absorption and convection are proportional to the difference of temperature of the heated substances and the heating medium, the constant varying with the different substances.

Heat distribution and heat absorption are very closely related and cannot be considered independently. In firing porcelain, there are four (4) distinct danger zones:

1. The ware is heated up until it reaches the boiling point of water.

2. When the contained water of crystallization begins to break up—this zone to consider safely is between 750° and 900° F.

3. Where the less refractory ingredients begin to fuse and the whole mass becomes more or less soft. The firing between these stages can be quite intensive

4. After the firing (soaking zone) cooling begins, and with some material rapid cooling is permissible to the temperature of a dark red. After that a gradual and slow cooling is necessary.

[1] Received February 27, 1920.

The above brief summary of the danger zones shows that the very exacting requirement in firing porcelain is obviously difficult to observe, when applying to the beehive kiln. The heating of the whole mass of ware and saggers cannot be easily accelerated or retarded rapidly.

This brings us to an arrangement where a proper cycle may be obtained by localizing the intensity of heat in certain portions of the kiln and have the section so proportioned that the material being moved at constant speed is for a longer time under the influence of the heat at the point in question.

The main factors controlling heat distribution and heat absorption in a tunnel kiln are: (*a*) Size of the car, (*b*) amount of ware on the car, (*c*) size of passages. Items *a* and *b* are usually predetermined by the output contemplated. It is really the proportion of the passages and the combustion chamber that determines the performance of the kiln and its efficiency. Assuming that the kiln is proportionally designed to take care of the output, the question of proper firing becomes of the most importance.

There is no set rule for firing of all fuel, except the fundamental fact that sufficient space must be provided for combustible gases and proper provision made for the mixture of those gases with the oxidizing agent. Independent of the original fuel, it is the gases that produce combustion. In coal firing the gases are obtained by a partial distillation. In oil firing, the gases are either vapors or true gases of the oil, and the closer the state of the oil approaches the state of perfect gas the more efficient is the combustion. That is why oil-firing system that gassify the oil before combustion obtain higher efficiencies and higher temperatures. Gaseous combustibles are not only conveniently mixed in the proper proportion with air, but ignite immediately on coming in contact with the proper temperature without going through any intermediate stages.

The size of the combustion chamber is determined by the kind of fuel used. When solid fuel is used, large volumes of gases are distilled off and a large excess of air is usually employed. All this calls for a large combustion chamber. When liquid fuel is used, the combustion chamber may be somewhat less than with

solid fuel, but just big enough to give sufficient travel for the atomized or vaporized oil to gasify. When gaseous fuel or liquid fuel in gaseous state is used, the smallest combustion chamber can be employed.

It is interesting to note that with the truly gassified oil the size of the combustion chamber may be much smaller than if gaseous fuel is used. This is explained by the higher heat contents per cubic foot of gassified oil as compared with the natural, city, or producer gas.

When a concentrated gaseous fuel is used and the air is so controllable that an amount as close to the theoretical requirement as possible is used, the calculation of the combustion chamber to correspond with the proper distribution of heat is possible with a fair degree of accuracy. In firing ceramics, where the final result is obtained by a close following of the proper time temperature cycle, especially through the danger zones enumerated above, proper distribution of heat is vital. As distribution and generation of heat are closely interlocked, proper combustion is really the basic requirement for successful operation. The continuous kiln not only gives a proper distribution but allows flexibility of design of the combustion chamber.

The muffle type of kiln seems to be as yet the most efficient furnace for firing of porcelain as the passages for the production of combustion can be lengthened, widened, deflected or arranged in any way to correspond with the quantity and intensity of the heat required at any particular point. The proper length of the kiln is generally a matter of considerable discussion. In our opinion it is a matter of simple calculation and depends solely on the output contemplated and the time temperature cycle employed.

For the single tunnel kiln, if you multiply the length of the car in feet by the number of cars to pass through the kiln per day by the time in hours of complete cycle of firing, and divide by 24, you will get the length of the kiln If this item is not divisible by the number of cars add to this enough to make an even amount of cars. If this is a double compensating kiln, half of this length is sufficient.

As compared with a periodical beehive kiln, the continuous kiln has the following advantages:

1. The losses due to the defective placing, defective distribution of heat and inadequate control of the heat, are eliminated.

2. The ware is handled with maximum convenience as the placing is done outside of the kiln and only shoulder high.

3. The saggers are done away with. This not only means a saving of fuel, but a considerable saving in cost of saggers.

4. The losses due to intermittent heating and cooling of the kiln are eliminated.

5. Smaller up-keep expense.

6. The heat stored in the ware is utilized for preheating the incoming ware and the air for combustion.

7. The firing cycle is considerably shorter.

The double compensating kiln has many advantages over the single tunnel kiln, *viz.:*

1. It requires a shorter floor space for the same output. This gives a structure which is better proportioned for placing in an ordinary building.

2. Radiation losses are much less and therefore it is more economical. The middle wall of a double kiln takes the place of two outer walls thus saving one-half of the side surface radiation.

3. A better control of temperature and quantity of heat is obtained. As the heat is delivered to the ware by convection of gases and not by radiation from the walls, it is obvious that the distance that this gas will have to travel is the limiting feature in the control since these gases can be sent only a short distance without excessive loss.

4. Less initial expense for building and equipment. A double kiln requires half as much side plating and buckstays, wall insulation and usually less brick as the center wall is thinner than two side walls. The foundation is shorter and wider; this resulting in a better and stronger structure. Less attention has to be paid to expansion joints and piping is considerably shortened.

5. Less maintenance expense. The shorter the kiln, the fewer are the number of expansion cracks, which are inevitable in spite of all provisions for expansion joints.

With a properly designed kiln (that is, with a commercially scientific control of heat generation and distribution), firing ceases to be the problem of an expert. The cycle of firing once determined can be strictly adhered to, and anyone with enough intelligence to turn the valve in the right direction can be entrusted with the operation. It is not too optimistic to state that in the future, and let us hope in the near future, ceramics as an industry will be put on the same basis as any other manufacturing enterprise and the black magic of firing eliminated.

UNITED STATES SHERARDIZING COMPANY
PITTSBURGH, PA.

NOTICE—*Discussion of this paper will be published later as part of the Discussion of Tunnel Kilns.*

THE DRESSLER TUNNEL KILN FOR FIRING SANITARY WARE[1]

By George Brain

Owing to the erratic results that were being obtained at the plant of the Universal Sanitary Manufacturing Company at New Castle, Pa., during the year 1915, particularly with their glost firing, the management decided to take what might be called a very grave departure from the methods then in use for the production of the finishing gloss on sanitary ware and to build a continuously operated tunnel kiln, of the muffle type, known as the Dressler tunnel kiln, which incidentally was the first in America, and the first in the world for firing sanitary ware.

It seemed foolish to them to continue to place ware in saggers, and gradually bring the heat to the goods, and then cool, wasting time and enormous quantities of fuel. They were convinced that the right method was to maintain the temperature desired near the middle of the tunnel, bring their goods up to the heat, and then past to the cooling zone, using the heat from the goods, to help conserve the precious fuel, which they had been wasting for years in their intermittent kilns.

The potters would have argued, "we know we are getting fairly good results by our present methods. Well, anyway, as good as may be obtained with our present equipment which we know something about while we do not know what the results will be if we take such a step as putting in a continuous kiln as part of our equipment, which is all theory and remains to be proven."

I was not connected with the company when the decision was made. It is just possible, however, that had I been consulted as a potter, I would probably have advised against such a step. Therefore, I am not speaking as one taking pride in having made the proposition, but as an enthusiast after the event.

[1] Received February 27, 1920.

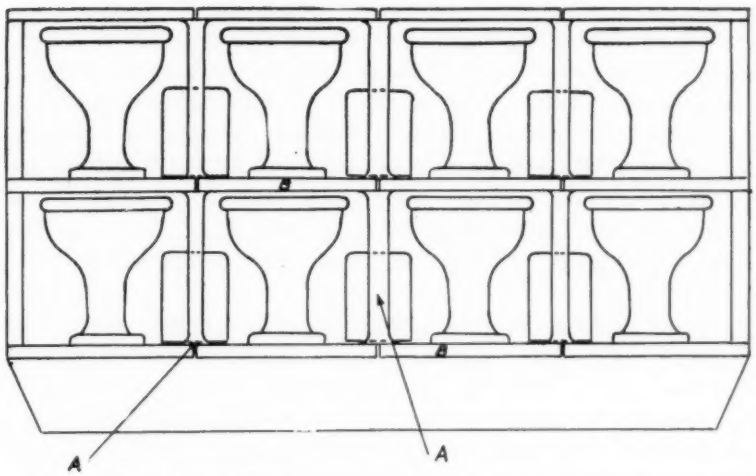

FIG. 1.—Side view of loaded truck. *B*, *B* are fire-clay slabs. *A*, *A* are supports on outside of slabs *B* used for supporting upper deck. Behind these supports and between the bowls small articles can be fired as described in the paper. It will readily be seen that by enclosing the bowls in saggers the space would be divided and thus ruined for use for extra pieces. The sketch shows one side of the truck holding 8 closet bowls and 6 jars, or a total for the truck of 16 closet bowls and 12 jars. When tanks are placed the total number of tanks that can be fired vary from 10 to 12 according to the size of the tanks.

The kiln is approximately 250 feet long and holds 44 trucks, each measuring 5 feet 8 inches long and 3 feet 6 inches wide. Each truck is capable of holding 18 large pieces of sanitary ware (8 tanks, 10 closet bowls). At 22 trucks per day (7 days per week) the production would be 396 pieces of sanitary ware per day, or figuring on a six-day basis for shop production, 462 pieces per day from the shops. We have never been able to produce this amount. Our total production per day from the clay shop has never exceeded 360, so that the tunnel kiln has never been pushed to its capacity. Incidentally we are hoping to make the 450 mark this summer when we get our new casting shop in operation. The distance from the entrance to the maximum temperature zone, speaking in trucks, is 28 and from there on to the end of the kiln is 16 trucks. Based on a maximum production

of 44 trucks per day, or one per hour, the time occupied by the ware from placing in kiln to time of coming out is only 44 hours. Adding to this the extra six hours given for cooling, in an antechamber provided on our return truck, the time occupied is 50 hours, from placing to packing shed. Compared with the intermittent kilns there is a saving of the difference between six days (144 hours) and 50 hours, which equals 94 hours, which means that the time occupied by the process of glazing is cut down by about 60 per cent. Compare the amount of fuel used in each case.

An intermittent glost kiln will use about 250,000 cubic feet of gas per kiln, or if coal is used, about 15–16 tons. The Dressler kiln uses 50,000 cubic feet of gas per day or intermittent kiln equivalent. If using coal in a gas producer 3 tons per day or intermittent kiln equivalent will suffice—an actual saving of four-fifths, or 80 per cent, of the fuel, which in itself is not to be taken lightly during this period of high cost of living.

It is interesting here to note that when on a few occasions we used saggers on several trucks our production per truck was cut down from 18 to 10, or 44 per cent. In addition to this, when using saggers we were not able to fire smaller articles without providing extra space for them. The reason for this you will readily see. On each side of the truck (lower deck) we fire 4 closets, or 8 in all, which leaves 6 spaces to be filled. All kinds of articles fairly large in size, can be fired in these spaces, such as paper boxes, water coolers, etc., equal to a production of about 850 pieces per week.

On one occasion we took an order for a certain type of white jar for which we had to provide special saggers in the bisque. Had we continued to do this our profit on the jars would have been small. Instead we raised our heat in the tunnel kiln to cone 9, hardened our glaze a little and dipped the jars green, firing them but once through the tunnel kiln. We saved considerably on this, because in raising our heat from cone 7 to 9 we only used an extra 5000 cubic feet of natural gas per day, costing $1.75 —about one and one-half cents per jar.

These savings are worth while and were not thought of when the kiln was first installed. Firing without saggers has tre-

mendous advantages. Each piece of ware can be seen and inspected from the time it is placed until it enters the kiln. Our kiln operators are thus able to check any slips that our kiln placers may have made.

The saving in equipment and labor is also enormous. (1) Our men place all our ware during an 8-hour day, while 2 men working day (12 hours) and 2 men at night (12 hours) put the trucks in the kiln and unload same as they come out. (2) As all our slabs and supports are cast they stand up well. We use an average of two large slabs per day, and several small supports. You will readily see that the displacements of ware for firing these is very small indeed. This would not be the case with saggers.

Based on a production of 70 green saggers per day (35 rings and 35 bottoms) there would be a displacement of 35 pieces of ware, which, based on a profit of $12^1/_2$ per cent, would mean that the company would be the loser of $12,000 each year, irrespective of what it cost to make the saggers and the space occupied by the saggers and sagger room. Wadding is entirely eliminated. This effects a direct saving of thousands of dollars per year, which any manufacturer will appreciate.

Six men, including kiln placers, operate our Dressler kiln, working a total number of 64 hours per day, or, based on a 7-day week or a 7 intermittent 16 feet 6 inches kiln equivalent, 448 hours per week.

Let us see how many men it takes to produce 7 intermittent kilns per week. Seven 16 feet 6 inch kilns will average 50 bungs, or 350 bungs per week. Each union kiln placer sets 7 bungs per day (8-hour day) or it takes an equivalent of 50 times 8 hours per week equals 400 hours for kiln placing. Drawing the same kilns finds work for 10 men each time a kiln is drawn, of 5 hours each kiln or 50 hours per kiln for whole gang, or 350 hours per week. It is fairly reasonable to say that 1 fireman and 4 helpers will fire 7 kilns per week. One fireman 8 hours per day for 6 days equals 48 hours per week. Four helpers 12 hours equals 48 hours per day or 7 days equals 336 hours per week. It is safe to assume that it will take an extra laborer for punching and cleaning up 8 hours per day for 6 days or 48 hours per week.

Unloading 105 tons of coal 10 hours per week. Just these alone will give the huge total of 1192 hours per week for the same product as one tunnel.

In using the number of hours per day as a comparison, I believe I am able to show you without giving you actual dollars and cents exactly what we save on labor alone. Let us compare —448 hours per week for Dressler and 1192 hours per week for seven $16^1/_2$ ft. kilns, a saving of 6.44 hours per week or in percentage about 55 per cent.

Had it been necessary for us to use saggers in our Dressler kiln it will be readily seen that our labor saving would have been very small, besides which we would have cut down the production to an enormous extent. Had saggers been used one bottom and one ring would be used per piece of sanitary ware. Our kiln placers instead of handling 400 pieces of ware or thereabouts would have to handle 400 pieces plus 800 saggers with necessary wadding. That of course is assuming for sake of comparison that the same number of pieces could be fired with saggers; as a matter of fact the actual production would be cut in half and even at that would give the two kiln placers more work than they could handle. It is very easy to see that our kiln placers would be multiplied by 3, or instead of 2 we could need 6, and at least 4 extra men would be needed for the drawing irrespective of the extra cleaning up that would be necessary. The labor saving appeals very much to me indeed, especially with regard to kiln placers. Where could we possibly get 4 extra kiln placers, not to speak of kiln drawers? As matters stand in the skilled labor world, it is next to impossible. They would, however, be necessary, if we used saggers, which certainly would be the case if it were not for the fact that our kiln is of the muffle type. It is not that we save money on the labor so much as the fact that we are able to operate with so few laborers.

In regard to quality it may be said that we are able to steadily produce goods of first-class quality, with none of the glost defects so prone to crop up in saggered kilns of any description which are direct fired.

It will be interesting here to note what our repairs have cost us during 4 years of operation. Three years ago we decided to

repair the arch in the heat zone which had sunk about 3 inches owing to low-grade fire brick having been used. We made a number of arch bricks ourselves from what we considered after a series of tests would give us good results. Six hundred were used in all and they are in the kiln to-day in first-class shape. We have also used 20 to 25 sections of combustion chambers during four years, not a terrible expenditure by any means, either in labor or materials.

Since the first few trial trips in the fall of 1915, when we shut down the kiln to make any improvements the operating had suggested to us, we have had one run of fifteen months and two of twelve months each. Twelve months ago we voluntarily shut down when the sanitary business was at its lowest ebb. Had this not been the case I firmly believe we would have run for a full two years—not at all a bad record for a kiln operating at cone 7 and part of the time at cone 9.

UNIVERSAL SANITARY MANUFACTURING CO.
NEW CASTLE, PA.

NOTICE—*Discussion of this paper will be published later as part of the Discussion of Tunnel Kilns.*

DISCUSSION OF TUNNEL KILNS*

MR. GILL: On account of the heavy nature of the ware we put through the kiln we have to keep the hot zone at 2400 to 2500 degrees F, about 2400 degrees on the average, and the ware is about three days in the hot zone. We run a little more slowly than some of the gentlemen, about 2 feet an hour, on account of the weight of the ware. The cars moving through the kiln are covered with a refractory material that we manufacture ourselves. This is in the shape of a large block about 8 inches thick placed on top of the cars and ventilated with holes so as to allow the circulation of the heat all through the ware that is on top. I am sorry we did not have some one to explain the working of these kilns before we talk about the results, about the way the kilns are cooled below and the scientific manner in which the drafts of the kiln are taken care of. It was remarkable to me that we could have a heat of 2400 degrees in the kiln and a downpour of heat into the space below the cars not hot enough to light a piece of paper.

MR. J. B. SHAW: I do not know whether the gentlemen stated or not, but I have heard that they have eliminated saggers and seals.

MR. C. DRESSLER: I shall be very pleased to answer any points on which you may wish information. First, let me say that I much object to hearing the Dressler kiln so often referred to as a muffle kiln. This description appears to me an inadequate one. The most important point is overlooked when you talk about it as a "muffle kiln." A muffle, we know, consists of one fire-clay box within another, the flames passing between the two shells, and, in the Dressler kiln, we are not doing that at all. We did not adopt the internal combustion chamber primarily because we wanted to keep the flames from the goods. Our main purpose was the control of the flame—to burn the fuel

* Annual Meeting, February 25, 1920.

completely, and without excess of air, and, therefore, as economically, efficiently or scientifically as possible. Our second, a not less important purpose, was to impart the heat thus produced to the goods with uniformity throughout. You know that it is quite impossible to burn gases efficiently if you let them loose among the goods, and that truth applies to all forms of fuel. No mean exists by which you can regulate the mixture of air and fuel in an open kiln, whether periodic or continuous. Seger tells us that after numerous investigations, in the continuous circular or ring kiln, he never found less than ten times as much air passing through it as was needed for combustion. Well, 12 cubic feet of air weigh one pound. The weight of this excess of air in an open kiln calls for a fuel expenditure of not less than 55 to 60 per cent over and above that which is really needed if the fuel is accurately burnt as in the Dressler kiln. You realize what that means on your fuel bill. The analysis of our burnt gases shows as high as 19 per cent of CO_2. This is practically the maximum possible.

I must again point out the benefit of control. It is the whole secret of progress. By its means, we can apply the heat just where we want it. We can lengthen or shorten the heat zone at will. In fact, we decide what the heat curve shall be and are masters of the heat, not mastered by it.

Now, we do something more than this. By means of our chambers, we are able to use only hot air of recuperation—not cold air which is used in so many cases. This is a great saving. Further, we are able to recover nearly all of the remaining heat from the fired goods, in the form of hot air. The fuel value of this is not less than 40 per cent of the calories put into the kiln. Thus, where it has been usual to fire goods in a periodic kiln with twenty tons of coal we are able to do the same work with, say, five tons. Only three of the five are used for actual firing, and we return two tons' worth as hot air. That will be something acceptable to those who have to dry their goods. This is a distinctive feature of the Dressler kiln.

To answer Professor Shaw's question, it is by the same means of control that we keep the heat from affecting the metal parts of the truck. We were able and very glad to give up the use of

sand seals, because the convection currents which take place at the level of the benches of the kiln are so intense that they practically keep the heated air from penetrating below. These convection currents exist for the whole length of the heating zone. I do not mean to say that we have not got radiation at certain points. When we come to the hottest point radiation overtakes convection and here it helps us, because by that time the goods are thoroughly permeated through and through with heat. You know the difference between radiation and convection as well as I do. You know that you can toast a piece of bread quite brown in a very short time if you hold it in front of a hot radiating fire, while the other side will remain white and cold. On the other hand, if you interpose ever so thin a screen, you will never make the toast. It is equally evident that the screen between the inner chamber and the goods prevents the radiation which will produce the undesirable inequality of heat distribution. That is the secret of our uniformity of heat throughout the goods. You have heard Mr. Gill tell you about it in actual production and there is therefore no use in my going into further explanations.

With regard to any heat which travels down through the body of the car by conduction, this we remove by means of cooling pipes, drawing it off in the form of hot air or, in some cases, hot water. In the former instance, this heat, small as it is, is added to that which the manufacturer can have for his drying purposes. In this way, the metal parts are kept so cool that, as you have heard, paper will not char when fixed to the under part of the cars, even after an exposure of five days in the kiln.

Mr. Sproat has spoken of the trouble he has had with tar and so forth, which he has now, however, overcome. This is a producer trouble. Where so many different types of fuel are used a trial period is necessarily first experienced in the gasification. With anthracite or coke there is no trouble. Where bituminous coals occur, which lead to more or less caking and clinkering, it is necessary to find out the best way of handling the producer so that a smooth production of gas may take place.

One more thing I would like to say. Some people seem to think that our kiln, having such very thin-walled combustion chambers, must be a very delicate apparatus and one suited only

for delicate ware—not for such products as brick, paving blocks and heavy materials of that sort. You have seen on the screen the glass tank blocks, which we fire. They do not appear very delicate affairs. As regards large outputs and big weights, I may tell you that we have kilns at present firing no less than 300 tons of material in 24 hours, which, in terms of brick, would be equivalent to 100,000 per day, and this production goes on year in and year out, in some cases for three years without a stop. That is my answer to anyone who is afraid that our kiln is no suited for the production of large quantities of common building materials.

MR. E. K. PROODIAN: If you have a breakdown in the muffle how long does it take you to get into the kiln and replace the muffle and heat it up again?

MR. C. DRESSLER: That depends a great deal on the heat of the oven, and so forth, but I think ten days.

MR. ELLSWORTH OGDEN: I would like to call attention to one statement Mr. Dressler made, that he felt it was impossible to get perfect combustion, or impossible to control the combustion anywhere outside of a muffle. Now, as a matter of fact, in this muffle he must control the combustion. If he gets an excess of gas, combustion will take place too far down in the tunnel, and if he gets too much air, his flame will be too short. So he must control his combustion even inside that muffle in order to get the results he wants. Now, then, the advocates of open firing maintain that if your fire boxes, or your furnaces, or combustion chamber, or whatever you call it, are properly designed, you can control the combustion within that chamber just as perfectly as it can be controlled within the interior of any other combustion chamber; and if your combustion is properly controlled then the products of combustion are free from a reducing effect. They contain only the normal products of combustion and whatever sulfur your fuel has, and they are not injurious to the ware any more than those in any other type of indirect fired kiln. It is a question of control of combustion, whether you control it inside of an inner wall or within an ordinary combustion chamber and in the direct-fired kiln it has been possible to control this com-

bustion so that there is an entire absence of flame in the tunnel at all times.

MR. SAMUEL TROOD: To emphasize Mr. Ogden's statement, I may say that to create combustion, a combustible, oxidizing agent, proper temperature and thorough mixture of the above are necessary. Assuming that the combustion chamber is correctly figured, the temperature obtained is such that by increasing or decreasing the oxidizing agent the temperature falls down, thus creating a chemically neutral quality of the flame. Let us call this condition 100 per cent. With the deficiency of air up to 30 per cent, the temperature will gradually fall and still create a smokeless combustion with gases of reducing nature. With a still greater deficiency of air the combustion becomes smoky and uncontrollable. With excess of air up to 30 per cent the temperature will also go down, the flame will be smokeless and the gases of oxidizing nature. With further excess of air the combustion becomes uncontrollable.

It is possible to fire a kiln with direct flame, producing desired results, especially if the combustion chambers are placed outside the kiln and if the supply of combustible and oxidizing agents is under full control. In the Kirk muffle tunnel kiln recently constructed for the Westinghouse Electric and Manufacturing Company, neutral or reducing atmosphere in the combustion chamber was created at will.

MR. A. F. GELLAR: Can a tunnel kiln be operated at cone 18 economically?

MR. J. B. OWENS: Yes sir. In the direct-fired tunnel kiln that we are building we give in one of our movements a six-hour soaking heat. We go up gradually and can go from practically atmospheric condition up to 2500 degrees F or almost as much higher as you desire to go, certainly away beyond cone 18, because we have burned up to 2900 degrees F. At the cooling end of the kiln, the ware cools almost perfectly. Now this was not the case when we were experimenting on tunnel kilns, because the first tunnel kiln we built was only 160 feet long and had only one firing zone. Today we build our kilns 240 feet long, and they are as near perfect as a tunnel kiln can be built, and we can prove

it to any man who has a prejudice or who doubts the proposition. When you can take a direct-fired tunnel kiln and operate on a one-hour movement, six hours' soaking, then you really have a kiln. Every man here knows that clay ware must be burned through and through, that he can not burn the outer surface only and still have a good product, that it must be burned to the center just as well as the outside, and that a soaking heat is absolutely necessary to secure this result. Another thing every one here should understand is that a direct-fired kiln must, of necessity, have a greater capacity than any kilns which have frills and furbelows.

MR. E. C. STOVER: I would just like to ask the cone 18 gentleman where he got his fire brick. Did he get them from Germany?

MR. J. B. OWENS: You can get many of them in America; cone 18 is only 2642 degrees F. We have burned way beyond that and the bricks stood the test.

DR. SAMUEL TROOD: I think they might stand for a short period but not for a year continually.

MR. J. B. OWENS: How much more is the heat in your fire-brick box than the kiln? The old type kiln I refer to. You ran your old type kiln to cone 12; how much hotter is the heat in your fire box than up in your kiln?

DR. SAMUEL TROOD: But they burn out.

MR. J. B. OWENS: Ours will burn out at times, but we have experienced no trouble of that kind except with one kind of brick.

DR. SAMUEL TROOD: How do you control the flame going right into the kiln?

MR. J. B. OWENS: We do not have any flame going into the kiln.

DR. SAMUEL TROOD: You call it products of combustion. I call it flame. How do you control the zones? By zones I mean places in the kiln where the temperature is to be raised or lowered. For example, how do you retard the temperature when the ware begins to reach 750 degrees and up to 900 degrees?

MR. J. B. OWENS: We do not retard to soak. Our heating

zones are large enough to give us the soak as the cars pull through. We never change our heat after the kiln is once full.

DR. SAMUEL TROOD: I appreciate that, but how do you install them in your kiln?

MR. J. B. OWENS: That is done by dampers in the walls of our kiln. We can control that as near perfectly, I believe, as it can be controlled.

THE CHAIR: I hope that within the next year some of our wealthy manufacturers will build one of these 18-cone kilns and give us the results at our next meeting.

MR. R. C. PURDY: One is now being operated at cone 16–17, in which they do reach 18 at times.

MR. STOVER: In Berlin they have a kiln in which cone 18 is produced, but I am asking where in America you can get a brick that will fire ware at cone 18?

MR. F. C. RIDDLE: May I make a statement which I think I can substantiate? Burning cone 19 down is perfectly possible and is being done in the United States in periodic downdraft kilns at least 14 feet in diameter. There are several types of brick that will withstand this temperature; and with the so-called super-refractories, it is possible, if you want to spend the money, to burn cone 26 down if you have fuel that will do it.

MR. E. C. STOVER: Would you mind giving us the address?

MR. F. C. RIDDLE: I know that Hy-Brand brick will stand up at cone 18, and there are several others.

MR. HOWELL: In the past six months I have come in contact with 24 or 25 brands of fire brick made in England, Scotland, Germany and Sweden, and I believe there are a couple of brands from Canada, and with only one exception did we find any of these foreign bricks which were not fused or soft above cone 32. One brand which was called the Snowball fused above cone 32; but outside of that one brand, we did not find anything which would cause any serious competition with the better grade of American refractories.

DR. SAMUEL TROOD: We were talking about continuous kilns. So far as the best intermittent kiln, either downdraft or updraft

kiln is concerned, we do produce these results. I got them myself, but every time I burned down the kiln from the roof to the bottom. There is no question but that we can do it, but we are talking about a continuous kiln where the repair, as Mr. Dressler said, means ten days, and means not only considerable money, but ten days' interruption to production. As a rule, any reputable kiln builder employs carborundum blocks. The Dressler kiln has carborundum blocks and carborundum chambers and they stand.

A MEMBER: How long do you guarantee them to stand?

DR. SAMUEL TROOD: Until a foolish man comes along and puts in a charge of something that will blow them up.

MR. R. J. MONTGOMERY: In burning a tunnel at cone 18 (1500 degrees C–2732 degrees F) to use fire-clay refractories in the hot zone would be to invite trouble. There is too small a factor of safety in the material. The A. S. T. M. standard temperature for testing first quality material is only 1350 degrees and practically all fire brick will show a shrinkage when held at 1350 degrees C for $1^1/_2$ hours under a load of 25 lbs. per square inch.

A few brands might be found which will stand the load test without linear shrinkage of 2 per cent or more, but holding for months at a temperature of 150 degrees C higher would certainly cause some shrinkage. Also the fire-clay mortars are not as free from shrinkage as the brick. The total shrinkage of mortar and brick could easily cause the wall to sag. Probably complete failure would not occur with a very high grade brick, but undesirable shrinkage would certainly be obtained. Insulation for fuel economy would prevent the use of thin walls so only the inside surface would reach full heat.

The coke oven is a good example of where silica has replaced fire brick when continuous high heats are used. Cone 18 or 20 could be held indefinitely with no softening effect or shrinkage either on the brick or mortar. You still have a reasonable factor of safety and accidental overheating would not cause as much damage as with fire-clay refractories. Coke ovens have given 8 to 10 or more years of service with working temperatures from

1525 degrees C to 1575 degrees C without signs of failure from lack of refractoriness. There is no sagging of the wall and loss of alignment due to shrinkage.

DR. SAMUEL TROOD: I may emphasize that remark about refractories with a very few short words. During the war, being in charge of a metallurgical proposition in California, the question came up where to get refractories, that would stand in an electric open-pit furnace. You gentlemen know how high are the temperatures produced with direct process of ferromanganese. I could not get the refractories and used common brick, yellow brick at $40 a thousand. I made the walls quite thin, jacketed all around with boiler plate and water-jacketed the furnace. Of course, I paid considerably for that, but ferromanganese at that time was worth $410 a ton, and that would pay for any expense. That was one way a kiln could be built, by cooling the combustion chamber.

I had so far trespassed upon the time of the convention that I felt that I could not take up any more of it in answering Mr. Ogden. I am therefore glad of the opportunity given me of preparing a written reply. The difference between burning the fuel in a combustion chamber placed inside the oven, as in the Dressler kiln, and of burning it in a fire box placed outside the tunnel, in the case of an open fire tunnel kiln is considerable.

1. Our combustion chamber is controlled at both ends. All the products of combustion burnt in it pass into a flue with a damper to it. The products of combustion in the second case pass into the oven or tunnel, which has doors at each end through which air will enter every time the goods are put in or taken out and the flues therefore are drawing not only on the fire box but on the two openings in the tunnel. The difference in the control is evident.

2. Now with regard to economy, all the heat used in the period of incipient to complete combustion goes into the walls of the chamber. If this is outside instead of inside, all the heat which radiates from this chamber is lost.

3. In the open tunnel the air with which the fuel is burnt in the outside fire box is mostly cold. Therefore, the principle of recuperation is not used at all or only in a small degree. This

means that a large proportion of the fuel is used in heating up cold air.

4. As the burnt gases from this fire box enter the kiln, they encounter and mix with the cooler air, which enters the tunnel ends through the doors every time they are opened. All this air has to be heated up uselessly to the top temperature required.

Thus, though the air and fuel put into the outside fire box may be in the proper proportion, as soon as they enter the kiln, this proportion is entirely upset. It is only necessary to analyze the products of combustion to realize this. As a consequence of using the tunnel itself as a flue, an unavoidable variation of temperature in the kiln occurs every time the doors are opened.

THE CHAIR: We will have to consider that this closes the discussion. If you have anything further, we will ask the gentlemen involved to conduct the discussion by mail. The way this session has developed has been a source of considerable personal satisfaction to me. It was my desire to have this on the program last year, but for certain reasons it was not possible. I hope next year we will be able to continue this along with other sessions of interest to factory men.

NOTICE.—*Further discussion of this subject is solicited. All communications should be sent to the Editor.*

SPECIFICATIONS FOR COMMERCIAL FELDSPAR AND FLINT[1]

By Arthur S. Watts

Specifications Covering the Purchase of Pulverized Feldspar to Be Used in the Manufacture of Whiteware

I. The Sample.—In sampling car-load lots, equal amounts shall be taken from at least five different points in the car, no two samples being taken within five feet of each other.

In sampling from a bin, five separate samples shall be taken from different portions of the bin and not more than two from the same level. The total sample shall be not less than ten pounds. The samples shall be thoroughly mixed on a smooth surface divided in halves, one-half spread evenly over the other half. Repeat this operation five times. The mixed sample shall then be quartered and two quarters not adjoining rejected. The remaining quarters shall be mixed, as described above, five times, quartered as before, and two quarters rejected. The remaining sample shall weigh more than 2.2 pounds (1 kilo) and shall be placed in a tight receptacle, and marked with an identifying number or with the name of the material, car or bin number, and data on which sample was taken.

II. Chemical Composition.—1. Feldspar sold as potash feldspar shall contain not less than 9 per cent K_2O, and not more than 3 per cent Na_2O and not more than 1 per cent CaMgO, and the sum of the potash and soda contents shall be not less than 12 per cent.

2. Feldspar sold as soda feldspar shall contain not less than 7 per cent Na_2O, not more than 3 per cent K_2O, and not more than 2 per cent CaMgO, and the sum of the potash and soda contents shall not be less than 10 per cent.

3. Feldspar sold as mixed or blended feldspar shall contain not less than 11 per cent total potash and soda content.

[1] Received February 27, 1920.

III. Physical Properties and Tests.—1. Color. The feldspar when formed into a standard sized cone and deformed in a closed sagger or muffle shall show a uniform white color and no specks either on the surface or on the interior of the cone when broken.

2a. Fineness of Grain. One hundred grams of the sample, after being dried to constant weight at 105° C, shall be tested for fineness of grain according to the process set forth in paragraph *2b* and the residues on the various standard sieves shall not exceed the maximum totals as set forth in the following table:

Standard Sieve Mesh per Linear Inch	Each Sieve Per cent	Residues	Max. Total Per cent
65	0.25		...
100	.25		0.50
150	1.75		2.25
200	3.75		6.00
260	5.00		11.00
325	7.00		18.00

All percentages are calculated on dry basis.

2b. Method of Making Fineness of Grain Test. The 100 grams of dry sample shall be transferred to the sieve and placed over a sieve pan which fits closely enough to prevent loss by slopping. The pan shall contain sufficient water to reach within not less than $^3/_4$ inch or more than $1^1/_4$ inches from the pan. The sieve and pan shall be vibrated or shaken in such a manner that the water in the pan is splashed on the screen from below so as to wash the powder about and cause the material that can pass through the sieve to pass into the pan below. This treatment shall be continued until no more material can be removed. The residue and the sides of the sieve shall then be thoroughly washed with water by means of a laboratory wash bottle.

In the washing process no artificial means, such as shot, rubbing with the finger, and so forth, shall be employed to force material through the sieve.

The order of sieves used shall be as follows: Wash the sample on the 325-mesh sieve to remove all fines, as this facilitates an accurate classification of the coarse material. The material passing this sieve may be concentrated by evaporation to dryness and weighed, or may be immediately thrown away and its amount

determined by difference. The residue on the 325-mesh sieve is transferred to a 65-mesh sieve and washed as described above. The material on the sieve is dried and weighed. The material passing the 65-mesh sieve is transferred to a 100-mesh sieve and washed and this process continued on the 150-, 200-, 260- and 325-mesh sieves, in order named, the residues on each being dried and weighed.

3. Moisture Content. Unless otherwise specified, the purchase price shall be based on moisture-free material and the moisture content shall be determined as follows: 50 grams of the sample (paragraph 1) are carefully weighed out as soon as the sample is taken and placed in an oven where a temperature between 105° C and 110° C is maintained with proper ventilation. The drying period shall be 24 hours and the loss in weight at the end of that period shall be reported as percentages of the dry weight.

4. Fusion Behavior. Test cones of the material shall be made of standard dimensions, *i. e.*, $2^{7}/_{8}$ inches high by $^{9}/_{16}$ inch diameter across base of one face. Cones of similar dimensions shall also be made of a mixture of 75 per cent by weight of the feldspar being tested and 25 per cent by weight of flint of standard specifications, as set forth in the accompanying specifications. The use of an organic bond, as dextrine or gum arabic, is permissible to insure the cones retaining form prior to fusion, but such added material must burn out completely and not affect the color of the material.

The fusion behavior of the different feldspars shall be as follows:

(*a*) Feldspars sold as potash feldspars shall fuse with or prior to standard Orton cone 8. The mixture of 75 per cent feldspar and 25 per cent standard flint shall fuse with or prior to standard Orton cone 9.

(*b*) Feldspars sold as soda feldspars shall fuse with or prior to standard Orton cone 7. The mixture of 75 per cent soda feldspar and 25 per cent standard flint shall fuse with or prior to cone 8.

(*c*) Feldspar sold as mixed or blended feldspar shall, if it contains more than 4 per cent soda, fuse prior to cone 7. The mixture of 75 per cent mixed or blended feldspar and 25 per cent standard flint shall fuse prior to cone 8.

5. Shipping Conditions. All material purchased under these specifications shall be shipped in clean, closed cars.

IV. Rejection.—The purchaser reserves the right to reject any portion or all of the material which does not conform to the above specifications in every particular and to return the rejected material to the manufacturer or seller for full credit at price charged F. O. B. point of delivery specified by the purchaser. If the material is to be replaced, a new order will be entered at prices, terms, and conditions acceptable to the purchaser.

Specifications Covering the Purchase of Pulverized Flint to Be Used in the Manufacture of Whiteware

I. Sample.—Same as paragraph 1, Feldspar Specifications.

II. Chemical Composition.—The material shall conform to the following limits of chemical composition:

SiO_2 not less than	99.60%
KNaO not more than	.15
Fe_2O_3 not more than	.05
CaO not more than	.10
MgO not more than	.10
Al_2O_3 not more than	.10

III. Physical Properties and Tests.—1. Color. The flint when formed into a standard cone and fired in a closed sagger or muffle to a temperature of cone 8 shall have a pure white color both on the surface and interior and shall be easily broken with the fingers, indicating no fusion.

2. Fineness of Grain. One hundred grams of the sample after being dried to constant weight at 105° C shall be tested for fineness of grain by the process set forth in paragraph 2*b*, Feldspar Specifications, and the residues on the various standard sieves shall not exceed the maximum totals as set forth in the following table:

Standard Sieve Mesh per Linear Inch	Each Sieve Per cent	Residues	Max. Total Per cent
65	0.25		0.00
100	.25		.50
150	1.00		1.50
200	2.50		4.00
260	3.50		7.50
325	45.0		12.00

All percentages are calculated on dry basis.

3. Moisture Content. Unless otherwise specified the purchase price shall be based on moisture-free material and the moisture content shall be determined as described under paragraph 3, Feldspar Specifications.

4. Fusion Behavior. Test cones shall be made of the material according to standard dimensions, *i. e.*, $2^{7}/_{8}$ inches high by $^{9}/_{16}$ inch diameter across base of one face. An organic bond as dextrine or gum arabic is permissible to insure the cones retaining their form prior to fusion, but such added material must burn out completely and not affect the color of the material.

The flint when made into cones as described above shall not deform before cone 24.

5. Shipping Conditions. All material purchased under these specifications shall be shipped in clean, closed cars.

IV. Rejection.—The purchaser reserves the right to reject any portion or all of the material which does not conform to the above specifications in every particular and to return the rejected material to the manufacturer or seller for full credit at price charged F. O. B. point of delivery specified by the purchaser. If the material is to be replaced, a new order will be entered at prices, terms, and conditions acceptable to the purchaser.

OHIO STATE UNIVERSITY
COLUMBUS, OHIO

DISCUSSION

MR. T. A. KLINEFELTER: It is the experience of our firm that specifications of raw materials in general pay very decidedly. Flint and feldspar, as well as various types of clay, have proved no exception. Since, however, this is a field in which written specifications are not abundant, it is somewhat difficult to obtain material exactly meeting specifications by the occasional buyer who does have them. The supplier very naturally will prefer to deal with a buyer who is not "fussy."

It is the writer's belief that if written specifications were pretty generally in use by buyers, the material supplied to the trade would take a distinct advance in quality. It is sometimes hard to trace trouble to some one particular thing, and this is especially

true if no constant check is kept on material received. Moreover, without specifications one does not know exactly what he does want.

Every one is generally agreed that the fineness of grind of flint and feldspar has direct effect on vitrification, also that the fusion point of the feldspar varies greatly with the amount of flint impurity, and so forth. It is hard to find simpler, easier tests to check these two things than the ones proposed.

We have tested every car of feldspar and flint used at our plant for over four years for fineness of grinding under specifications somewhat more rigid than those proposed. It is our experience that the wet screen test gives a practical factory control plenty accurate enough for commercial purposes.

There is a human factor to be taken into account. For this reason the tests should be run preferably by one person. We have found, however, that if the tests are made by men of approximately the same degree of skill in handling apparatus in general, the difference is no more than would be shown by a second sample taken in a car and both car samples run by one person. We have found that 8 inch screens are much easier to handle than the smaller sizes, due to the fact that slopping over the sides is likely to occur in the case of the smaller sizes. Even if the screens finer than 200 mesh are not absolutely correct, the error introduced can not be as great as the difference which would be shown by two different samples from the same car.

A comparison of tests made on a considerable number of cars both at the grinding mills, dry, and the factory, wet, did not check at all. According to the dry tests at the mills all the cars were uniformly of fine grind. According to our tests a decided coarsening had taken place. The grinding mills admitted the shortening of time of grind but felt they were justified, due to their tests which showed no appreciable coarsening. It may be mentioned that the dry tests ran fully 10 per cent below the wet test figures, and variations between cars were very small. We felt, however, that the wet test more nearly covered our conditions, as cars which ran coarser according to our tests, gave heavier knockings on the body lawns.

The above experience does not really warrant condemning the

dry test method, as the difference may have been due to the different methods used in washing the material through the fine lawn at the start. In both methods the sample is wet-screened through the finest lawn. In our case it was washed through in the manner described in the above specifications. By personal observation later at the mill, the writer found that the first washing was being done by holding the screen under the water tap, allowing a fairly strong stream of water to run through. This may have resulted in forcing some material through which would not have passed through normally.

When the car checking was started considerable work was done to determine the accurate, and at the same time the most time-saving manner of handling the test. It was found that if the whole 100-gram sample were placed on the coarsest screen and washed through the whole series the result would run 3 to 4 per cent higher than if the sample were first washed out on the finest lawn before starting it through the series, and a much longer time was taken also. Moreover, a second washing of the whole set with clean fresh water would generally get an appreciable amount through which had not been washed out the first time. While it is true that prolonged washing with plenty of water would give as good results, the time was practically doubled, with less certainty of accuracy.

Two samples from the same car sample would almost invariably check within a few tenths of a per cent, if the samples were first washed through the fine lawn, while there would be two or three times as much difference by the other method, unless very prolonged washing with plenty of water was the rule.

After all, what the factory man wishes is to know whether or not he has been shipped a grade of material which is coarser than his standard, and the tests outlined above will do this for him with sufficient accuracy. He is not interested in accuracy to the fourth decimal place. Moreover, it should always be kept in mind that the sample run is perhaps only 1/2500 per cent of the whole car, so that differences due to sampling are certainly larger than microscopic differences in lawn mesh.

It was our experience that the fusion test on every car was not particularly necessary in case we were dealing with mills

handling but a single grade of rock from quarries of good size. On the other hand, it is absolutely necessary when buying blends or from companies handling different feldspars. The mixed feldspar-flint cone gives a very close check on the action of the feldspar, at least accurate enough for all commercial purposes. The pure spar fusion is not enough to tell readily whether or not the feldspar is carrying more flint than you are allowing for.

In general, it has been our experience that the tests for fineness of grain and fusion can be made readily and quickly and furnish good commercial control. An hour will cover the time spent in handling the sample from any car.

MR. O. O. BOWMAN: I would like to ask Professor Watts why he runs the material through the fine lawns first and then goes to the coarser lawns? What advantages are obtained by this method?

MR. A. S. WATTS: Replying to the inquiry from Mr. Bowman, I would make the following statement: The idea in passing materials through the finest sieve and then returning to the coarse sieve is in order to remove first all that material which can not be handled by sieves. When this is removed through the finest sieve the material remaining on the sieve is then transferred to the coarsest sieve, from it to the next finer and so on in order that the residues may remain on the sieves and be dried rapidly. If the order were reversed, passing from the finest to the coarsest, the amount of water used would be very large and the material separated would require evaporation of the water or at least long settling or decantation, either of which would be much more tedious than the method suggested.

It seems reasonable to accept the claim of feldspar and flint grinders that a moisture content of not to exceed 2 per cent be allowed. Any amount of water in excess of this, however, should be considered as an adulteration.

NOTICE.—*Further discussion of this subject is solicited. All communications should be sent to the Editor.*

A DIRECT READING OVERFLOW VOLUMETER*[1]

By H. G. Schurecht

A direct reading overflow volumeter was recently designed by the Ceramic Experiment Station of the Bureau of Mines, for clay testing and has been found to be very efficient. This apparatus consists of a glass bowl (see figures 1 and 2) containing an overflow tube sealed through the bottom and extending into the interior. Underneath is placed a special burette graduated with reverse reading to catch and measure the overflow.

Operation.—Open stopcock of burette, fill bowl with an excess of liquid above the orifice of the overflow tube and allow to drain to constant level. In filling the bowl, the liquid should be poured against the side with a beaker, thus preventing formation of air bubbles. The opening in the overflow tube is made small so as to retard flow of the liquid sufficiently to allow any bubbles which might form to break, and to allow the liquid to come to constant level. A special burette[2] graduated to read zero when completely drained above the stopcock is recommended, thus eliminating the necessity of adjusting the burette to zero reading for each operation. When the burette has completely drained, the stopcock is closed. After carefully wiping the saturated briquette it is lowered into the bowl by means of a spoon. The briquette displaces a volume of liquid equal to its bulk volume, causing the displaced liquid to rise above the overflow orifice and slowly flow down the tube into the burette where the volume of the briquette is directly measured. The brass spoon for immersing the briquette is suspended by means of a hook from the top of the bowl, keeping the bottom of the spoon about $^1/_8$ inch from the bottom, thus preventing the possible error due to accumu-

* Read February 3, 1920, at the meeting of the Society in Philadelphia.

[1] By permission of the Director, U. S. Bureau of Mines.

[2] The bowls and special burettes were made by the Columbus Scientific Glass Works, 101 Mithoff St., Columbus, Ohio.

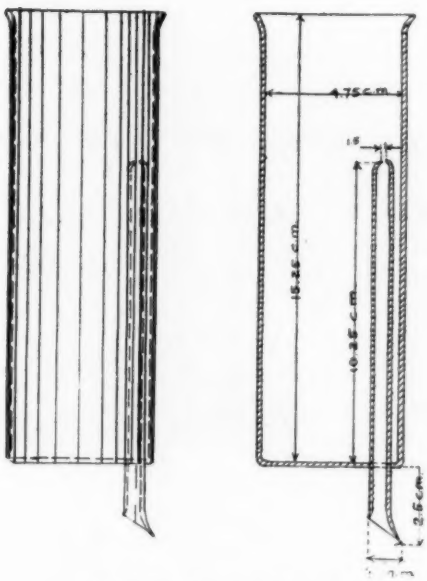

FIG. 1.—Volumetric bowl.

lation of dirt, which might change the volume of spoon immersed in case the spoon rested in the bottom of the bowl. The apparatus is allowed to drain about 10 minutes before reading. Reading of the burette is conveniently accomplished by the aid of a small magnifying glass and sliding gauge.

A battery of about 25 volumeters may be operated as a unit, thereby obviating the necessity of the operator remaining idle while the volumeters are draining. The liquid from the burette is caught in a copper trough and when kerosene is used is filtered through muslin, placed in a glass funnel, thus eliminating dirt from the oil.

Sources of Error.—The accuracy of the apparatus depends largely on its freedom from vibrations such as occur near machinery or are caused by the vibrations of floors, and the limits of accuracy within which the meniscus of the burette may be read. Vibrations produce surface waves, thereby causing an excess of liquid to flow through the overflow tube.

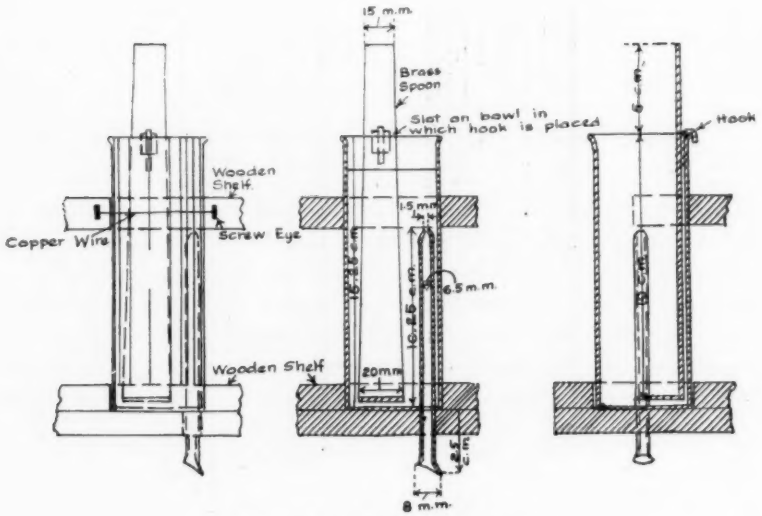

FIG. 2.—Glass volumetric bowl.

It was found that clamps, such as the universal type, could not be used to support the bowls unless an extremely short arm was used, as a long arm facilitated vibrations. In the Bureau of Mines ceramic laboratories no clamps are used for this apparatus, but instead well-bracketed wooden shelves to which the volumeters are held firmly by tightly twisted wires. The shelves are bolted to a 22-inch brick wall of the building, away from all vibrations of machinery and are not perceptibly affected by floor vibrations.

The diameter of the bowl should be kept as small as possible, thus increasing the accuracy of the determination. The bowl shown in figure 1 was designed for briquettes $1^1/_8$ inches $\times$ $1^1/_8$ inches $\times$ 4 inches, having a volume of about 80 cc.

Advantages over Other Types.—The error due to lodging of clay or grit in the stopper, which is one objection to the stoppered volumeter, is obviated in the above-described volumeter. Error due to liquid adhering to the briquette, which is possible in the Shaw[1] type, is prevented in the overflow type since the

[1] J. B. Shaw, "Direct Volume Determination in a Volumeter of the Pycnometer Type," *J. Am. Ceram. Soc.*, **2**, 481 (1919).

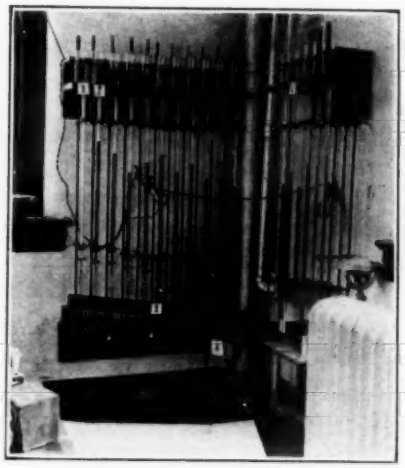

FIG. 3.—Battery of volumeter.

briquette may be wiped before immersion in the measuring liquid; also it is not necessary to determine the specific gravity of the immersion liquid as is the case with the pycnometer type. Corrections for the temperature of the liquid are also obviated. Ample time for draining (at least 10 minutes) should be allowed, when using the overflow volumeter.

Since the angle of capillarity of any liquid to a solid is constant for liquids of the same degree of purity and temperature and for solids of the same degree of cleanliness, the amount of liquid curving towards the sides of the bowl and burette are substantially constant in all cases, because these factors do not vary appreciably in the short time required for a determination. This is illustrated in the following checks made on a wrought iron bar of constant volume.

1	2	3	4	5	6	Maximum variation from the mean, per cent
77.80	77.80	77.85	77.90	77.80	77.85	0.0804

Comparing these determinations with those made on the pycnometer type volumeter,[2] the following results were obtained:

[2] H. G. Schurecht, "A Pycnometer Operated as a Volumeter," *J. Am. Ceram. Soc.*, 1, 556 (1918).

1	2	3	4	5	6	Maximum variation from the mean, per cent
77.90	77.90	77.90	77.90	77.85	77.85	0.035

It appears from these results that the pycnometer is slightly more accurate than the overflow type, and where greater accuracy is desired or if the volumeter is to be used in a room near vibrating machinery, the pycnometer type is recommended.

However, the overflow volumeter is sufficiently accurate for clay testing[1] and the operating time using a battery of volumeters is about 60 per cent less than that required for the pycnometer volumeter even when time-saving devices such as charts and tables are used with the pycnometer type.

Since the error is considerably less than that allowable, the overflow volumeter is recommended for clay testing because of its speed and simplicity of construction and operation. In conclusion the author wishes to acknowledge his indebtedness to Mr. R. T. Stull for helpful suggestions in the construction of the apparatus.

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[1] In calculating the drying and burning shrinkages of 15 different clays it was found that the variation of the shrinkages of different briquettes of the same clay from the mean averaged about 1.10 per cent. This variation was due mostly to the variability in shrinkage of the briquettes themselves.

NOTICE.—*Further discussion of this subject is solicited. All communications should be sent to the Editor.*

A FACTORY METHOD FOR MEASURING THE VISCOSITY OF POT MADE GLASS DURING THE PROCESS OF MANUFACTURE TOGETHER WITH SOME DISCUSSION OF THE VALUE OF VISCOSITY DATA TO THE MANUFACTURER[1]

By Edward W. Washburn

I. Principle of the Method

1. Introduction.—Of the various methods which have been suggested or used for measuring the viscosity of highly viscous liquids, the one best adapted to the measurement of the viscosity of glass over a wide range of temperature, including the highest temperatures (ca. 1600° C), attainable in practice, is the method which may be descriptively designated as the "stirring method." In its simplest and most exact form the apparatus consists of two co-axial cylinders between which the liquid is placed. One of the cylinders is then rotated and the torque exerted upon the other, for a given angular velocity, is determined. From these data and the dimensions of the apparatus it is then possible to compute the viscosity of the liquid by means of the laws of hydrodynamics.

Viscosimeters based upon this general principle and differing only in the system of regulating or measuring the two variables torque and speed, have been used by a number of investigators.[2]

2. A Laboratory Apparatus.—An apparatus of this type in use in the laboratories at Illinois for measuring the viscosity of glass is shown in figures 1 and 2. The pot, cover, and stirring

[1] Received February 27, 1920.

[2] For example, the viscosimeters of Gurney, *Phys. Rev.*, **26**, 98 (1908); Clark, *Trans. Amer. Cer. Soc.*, **12**, 383 (1910); Stormer, *Ibid.*, **11**, 597 (1909); Veinberg and Smirnoff, *Jour. Russ. Phys. Chem. Soc.*, Phys. Div., **44**, 4 (1912); Harrington, *Phys. Rev.*, **8**, 739 (1916); and Field, Bureau of Mines, *Tech. Paper* **157** (1916).

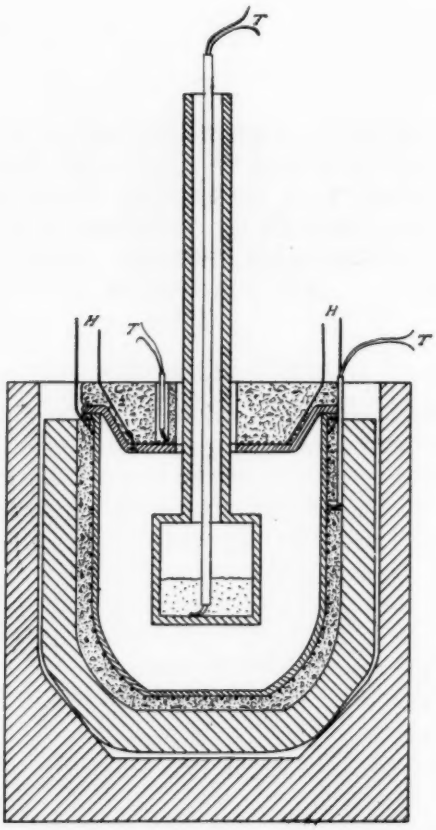

FIG. 1.—*H*, heating coils; *T*, thermocouples giving identical temperature readings.

cylinder are of porcelain and the heating coils of platinum. In using this apparatus the stirring cylinder is directly connected to the shaft of a specially designed motor and the power consumption P (or a proportional quantity) of the motor armature, when the angular velocity of the stirring cylinder is ω, is determined. If k is the calibration constant of the pot and P_o is the power requirement for overcoming any mechanical and electrical

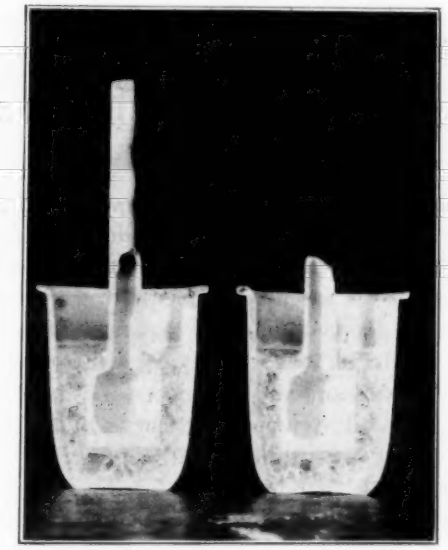

FIG. 2.—Cross-section of crucible, glass, and stirring cylinder.

friction in the driving mechanism, the viscosity η of the glass is then given by the expression [1]

$$\eta = \frac{k\,(P - P_0).}{\omega^2}$$

With proper attention to details of design this apparatus is capable of a high degree of accuracy.[2] The calibration constant

[1] Or more exactly by the expression $\eta = f\left(\frac{P - P_0}{\omega^2}\right)$, the form of this function being determined by measurements with liquids of known viscosity. For all practical purposes, however, it is probable that equation (1) is sufficiently close to the truth for work with glass, provided proper choice is made of the calibrating liquid and due attention is given to centering the pot and correcting for the varying depth of the melted glass at different temperatures. In any case the method of calibration described below will take care of this matter.

[2] A detailed discussion of the theory of the method, the design and construction of the apparatus, the procedure in carrying out the measurements, and the results obtained with various types of glass will form the subject of a uture publication.

k is determined with the aid of standardized solutions of a hexose in water, which at ordinary temperatures duplicate very exactly the properties of glass at high temperatures and thus constitute ideal calibrating liquids.

II. The Factory Apparatus

3. General Features.—From the foregoing brief outline of the laboratory apparatus it is clear that during the factory operation of stirring a pot made glass with a mechanical stirrer there exist nearly all of the essential elements of a viscosity apparatus on a large scale. To complete the apparatus it is only necessary to attach a wattmeter and a frequency meter (or other speed indicator) to the motor, and the necessary data for computing the complete viscosity-temperature curve of the glass can then be obtained during the ordinary stirring process without in any way interfering with that important operation. It is true that the data obtained in this way with the ordinary stirring equipment now in use will probably not be very accurate; but with certain improvements in the design of the stirring equipment, the accuracy attained can be very materially increased. The nature of some of these improvements will be briefly indicated, in the hope that some factory or institution having the necessary facilities will be interested in constructing a stirring outfit which will permit a thorough test of the proposed method on a factory scale.

4. Measuring the Temperature of the "Metal."—In correlating the viscosity measurements with the temperature of the molten glass in the pot, it is important that the method employed for measuring the temperature shall be accurate and shall represent as closely as may be the *average* temperature of the glass. If possible, a time-temperature curve should be automatically recorded covering the operation while stirring.

In a recent paper[1] on the "Use of Optical Pyrometers for Control of Optical-Glass Furnaces," Fenner has discussed some of the advantages and disadvantages of the optical pyrometer as an instrument for determining the average temperature of the

[1] Fenner, *Bull. Amer. Inst. Min. and Met. Eng.*, **151**, 1002 (1919); cf. also his paper on "The Technique of Optical Glass Melting," *Jour. Amer. Ceram. Soc.*, **2**, 138 (1919).

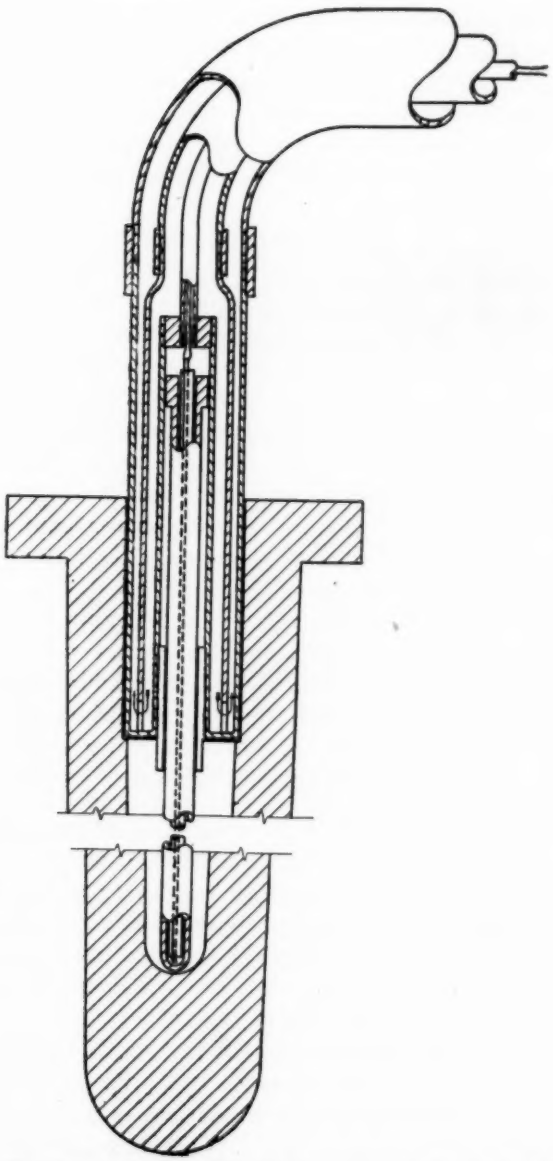

FIG. 3.—Showing method of inserting thermocouple in stirring thimble.

"metal." It would seem after reading his discussion of the matter, that the most logical method of following the temperature of the "metal" *throughout the stirring operation* is by means of a properly protected thermocouple placed within the stirring thimble. There may be some reason why this is not practical on a large scale, but at all events the method would seem worthy of a trial.

A convenient arrangement for connecting the thermocouple to the stirring arm, so as to insure its proper placing in the stirring thimble each time, is illustrated in figure 3. The thermocouple sheath (*e. g.*, of dense refractory porcelain) is held in place in the end of the stirring arm by means of a screw, through which it has, however, free play in a vertical direction. The compensating leads which connect with the thermocouple wires within the water-cooled region may, if desired, be made of the special alloy employed by Fenner[1] in order to eliminate thermoelectric forces at the junction, although, even with copper leads, the total correction would amount to only about 10° C and may be made without introducing any appreciable error.

With this arrangement a recorder can be employed and thus a permanent record secured of the time-temperature curve throughout the stirring operation. The method of attaching the thermocouple suggested in figure 3 has the further advantage of permitting its easy replacement or its removal for annealing and calibrating, as frequently as may be desired.

5. The Motor.—The method may of course in principle be carried out with any type of motor but accuracy and convenience may both be increased by employing a motor whose design is adapted to the purpose in hand. It should be so constructed as to reduce both electrical and mechanical losses to a reasonable minimum and to render all such unavoidable losses as constant and as determinable as may be.

The details of the design and construction of the motor will vary with the nature of the power circuit of the factory and the character of the stirring machine itself and they may be safely left to the electrical manufacturers. The manufacturers should

[1] *C. p.*, p. 1005.

also "calibrate" any motor supplied for the above use. This calibration will consist in determining with the aid of a dynamometer the relation between the output of the motor and its power consumption, under various loads and at various speeds. Such data will obviously enable P_o in equation (1) to be determined with increased accuracy.

6. The Wattmeter and the Speed Indicator.—The motor should be provided with a wattmeter[1] and with some type of speed indicator. For the speed indicator, either a simple revolution counter, a tachometer or some type of frequency meter may be employed. If the speed of the stirring thimble is controlled entirely at the motor, the readings of the speed indicator can be substituted directly for ω in equation (1), but if a change of gears or pulleys is employed in varying the speed of the stirring thimble, the readings of the speed indicator should be multiplied by the proper gear ratio; or the speed indicator may in such a case be transferred from the motor to the stirring arm itself.

Both the speed indicator and the wattmeter can be connected to recorders so that a permanent record of both P and ω throughout the run can be obtained, if desired.

7. The Stirring Machine.—To avoid power losses from belt slippage, the design of the stirring machine should preferably be such as to permit direct connection to the motor. For the highest accuracy only *ball bearings* and accurately cut gears should be employed and these should be water-cooled wherever necessary.

The path described by the stirring thimble in the glass is determined by what may be called the "setting" of the stirring machine and the points in the machine where this "setting" is made should be provided with such scales, or slots as may be necessary to enable a given setting to be made and reproduced accurately.

[1] A dynamometer on an extension of the motor shaft might, of course, be substituted for the wattmeter, but would be less convenient and more expensive, though more accurate. If a direct current motor with independent field excitation is employed, an ammeter in the armature circuit may be used instead of a wattmeter as under this arrangement the field losses, on a constant voltage, are without influence.

These are the main improvements in the stirring machine which are required in order to attain the highest degree of accuracy. It is evident that *constancy* in power loss within the machine itself is the *main* requirement, but reduction of this loss to a minimum is of course desirable.

III. Calibrating the Apparatus

8. The Determination of P_o.—The determination of P_o is carried out by operating the machine without the load on it. This should be done for each "setting" and for a series of speeds on each "setting." From the data thus obtained curves can be constructed which will enable P_o to be read off for any condition of operation.

This method of evaluating P_o obviously assumes that it is independent of the load. This will be very nearly the case in the stirring machine itself, if high-grade, well-lubricated ball bearings and gears are used in its construction.

In the case of the motor the power losses will, of course, vary with the load and the necessary corrections can be obtained from the calibration curve of the motor, which curve, as mentioned above, should be obtainable from the manufacturers. It should be noted, however, that if no correction is applied for the variation of motor losses with load, the error introduced need not be large since most of it will be automatically taken care of in the process of determining the constant k. All of it may, in fact, be thus taken care of, if for each "setting" of the machine, the constant k is determined as a function of the load as explained further below. Moreover, as the temperature of the "metal" in the pot falls, P becomes large in comparison with P_o, so that errors in P_o need not be of great consequence except during the initial period of the stirring operation.

9. The Determination of k.—Since in the usual method of conducting the stirring operation in a pot of glass the stirring thimble is not allowed to approach very close to the walls or to the bottom of the pot, the constant k should be practically independent of the size of the pot and of the depth of the "metal" in it. As regards the dimensions of the stirring thimble the con-

stant k may probably be taken as directly proportional to the area of the thimble in contact with the "metal" or, if the motion of the thimble has a vertical component, then to the *average* area so exposed. This matter, however, perhaps requires some experimental investigation and it may be found necessary or desirable to confine the viscosity measurements to those settings of the machine which do not give a vertical component to the stirring thimble.

The constant k may be expected to be to some extent a function of the "setting" of the machine, and its value should be determined for each "setting." It ought not theoretically to depend materially upon the speed of the machine, at all events not within the speed limits ordinarily used. Further light on these points will also be available as soon as the study of the mathematical theory of the operation has been completed.

The value of k *per square centimeter* (or, if the stirring thimbles are sufficiently uniform in shape, *per centimeter*) of thimble immersed is determined, for each regular "setting" of the machine, from the data obtained during the stirring operation on any pot of glass, the viscosity-temperature curve of which has been measured in the laboratory. The viscosity at a single temperature is, of course, all that is required in order to evaluate k, but a knowledge of the complete curve will permit check values to be obtained or will enable the operator to eliminate any appreciable error in P_0 arising from the assumption that this quantity is independent of load. This elimination is accomplished by taking the values of k as determined at different points along the viscosity-temperature curve and plotting them against the corresponding values of η. From the curve thus obtained the proper value of k may be selected for any subsequent run with the same stirring machine and motor.

IV. The Use of Viscosity Data in the Factory

10. The Relation of Viscosity to Factory Operations.—The three manufacturing operations which are connected with the viscosity of glass are (1) the elimination of seed (by fining); (2) the elimination of striae (by stirring); and (3) the avoidance of one class of "stones" (by rapid cooling through a certain "critical"

viscosity region). There are so few data available on the viscosities of industrial glasses which can be correlated with factory experience in the above operations that it would indeed be foolhardy to hazard at this time the formulation of rules of procedure, expressed in terms of viscosity, for carrying out or controlling any of the above operations. It may be worth while, however, to point out what appear to be some of the improvements in perfection of control which might conceivably result from a knowledge of the viscosities of pot made glasses.

11. **As to Fining.**—This operation is dependent upon the surface tension of the glass and upon its vapor pressure and density as well as upon its viscosity, so that a complete solution of this problem could not be given in terms of viscosity alone. For given values of the other three factors, however (and it may be that their influence does not vary very greatly from glass to glass), it might be possible, in terms of viscosity, to express in a perfectly general way for all glasses the maximum temperature which the metal should attain in order to insure successful fining.

12. **As to Stirring.**—As regards the stirring operation, which in the case of optical glass is largely depended upon to insure homogeneity in the melt, the directions for carrying out and controlling the details of this operation can at present be expressed only in terms of temperature or "color," and these directions have to be determined anew by the expensive process of trial and error, each time a significant change is made in the "batch." It seems entirely possible, however, to give complete directions for stirring procedure in terms of viscosity alone and thus to express them in a perfectly general way which should be largely, if not entirely, independent of the batch composition. In order to accomplish this, however, it would first be necessary to know the viscosity-temperature curves for a few representative glasses for which a definite and successful stirring procedure has been established so that the necessary correlation can be discovered.

Similarly in the case of certain types of pot made glass where diffusion and convection instead of stirring is largely depended upon to establish homogeneity, the requisite heat treatment for

all such cases should be capable of general expression in terms of the viscosity-time product or some simple function thereof.

13. **As to the Cooling Period.**—The application of viscosity data to the cooling period would probably not be so simple since the "critical region" for a glass depends not only upon the viscosity but also upon the compounds with respect to which the glass is supersaturated and upon the degree of supersaturation. It is entirely probable, however, that a comparison of the viscosity-temperature curves of different glasses over their "critical regions" would throw valuable light upon the nature of the factors which exercise a controlling influence upon this part of the cooling operation. Similar comments would obviously apply also to the annealing operation.

It should be pointed out, however, that the "stirring method" of measuring viscosity is not a convenient one to employ at annealing temperatures and should be replaced by a method of a different type which it is planned to discuss in a future publication. The whole subject of what may be called the low-temperature viscosity of glass may in fact be looked upon as a special field in itself. In addition to its relation to the devitrification and annealing behavior of glasses it has also an important bearing upon the development of the "colloidal" type of colored glasses and glazes and upon the permanency of such colors with time and heat treatment. The same is, of course, true of opal glasses. The surface flow of glass in the polishing operation is, of course, also a function of its low-temperature viscosity. Together with its coefficient of expansion the low-temperature viscosity of a glass also determines the character of the joint between the glass and a metal, such, for example, as the joint in an electric bulb where the connecting wires are sealed in. The resistance of a glass to sudden temperature changes is also largely determined by the same two factors.

DEPARTMENT OF CERAMIC ENGINEERING
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DISCUSSION

MR. G. V. MCCAULEY: To one familiar with the wide variation of glass viscosities encountered in the temperature interval

from 1400° C to 700° C, the laboratory viscosimeter described above by Dr. Washburn will appeal strongly as the most adequate for use at the lower range of this temperature interval. Here the power consumed in stirring is relatively large and consequently the power loss in the mechanism would introduce less error. It recommends itself particularly for being adapted to the use of the thermocouple for low temperature measurements where the optical pyrometer becomes unreliable. Again, for temperatures below 900° C, where this method would be expected to supplant the more delicate elastic torque apparatus used by A. L. Field,[1] every part of the apparatus admits of rugged construction. Consequently sufficient torque can be applied either by a motor or by suspended weights to measure the very high viscosities encountered at temperatures suitable for annealing purposes.

The adaptation of the above apparatus to the measurement of pot made glass during the process of manufacture is, however, fraught with many difficulties. Some of these have been enumerated by Dr. Washburn. It seems worth while, however, to call attention to a certain dissimilarity existing between the laboratory apparatus described above and the stirring machines used in the glass industries.

It must be remembered that the actual stirring motion that is used in glass manufacture does not simulate the motion in the above-described laboratory viscosimeter. The motion of the stirring rod in the process of glass melting and fining is primarily a translatory motion through the glass. There is no rotation in general of the stirring rod about its own axis. Consequently the constant k of Dr. Washburn's calibration equation (1) would depend *materially* on the "setting" of the machine, *i. e.*, on the radius of the stirring circle.

Perhaps it would be possible to so construct a machine that would make the linear speed of the stirring rod through the glass independent of the radius of the stirring circle and dependent only on the speed of the motor. In this event the "setting" of the machine would not greatly influence the value of k, provided the stirring rod were kept far enough away from the pot wall and

[1] A. L. Field, Bureau of Mines, *Tech. Paper* 157.

were not allowed to describe too small a circle in the center of the pot.

While it may prove impossible to overcome all the obstacles necessary to make the apparatus yield accurate viscosity measurements at high temperature, it seems quite probable that it might be made to serve as an index of the proper viscosity at which the stirring should be stopped. Whether or not it can be made more sensitive for this purpose than the present method of temperature observation experience only can decide. As the viscosity of an average glass would increase about one-tenth of its value for a decrease in temperature of 5° C at the temperature where stirring is stopped, it would seem that with properly designed machinery a decrease of 5° C in the temperature of the glass, which is about the limit of accuracy of the optical pyrometer, should be easily observed by the resulting increase of 10 per cent in the power consumption of the stirring machine. At any rate the proposed method should entice some manufacturer who employs stirring machines to give it a trial to determine its possibilities.

CORNING GLASS WORKS
CORNING, NEW YORK

MR. A. E. WILLIAMS: In general determinations of the viscosity of glasses through the entire range of temperature from fining to their freezing point in the moulds is one of the most valuable set of determinations which can be made. The adapting of various glasses to the machines on which the finished products are to be manufactured depends to the greatest extent on this property, and much can be done in reproducing definite viscosity changes if the effect of various glass-making constituents on viscosity is known. A practical viscosity machine is, therefore, a great asset to the glass chemist.

The determination of the viscosity of optical glass melts during the process of manufacture would indeed be of great assistance, first, in determining the proper speed of stirring and, second, especially in determining the proper point to cease stirring. There is little doubt but what the striae, introduced by convection during cooling after stirring has ceased, promote the greatest loss of glass by coarse striae. The distance of travel of convection currents from the sides and bottom of the pots towards the center

depends to the greatest extent upon the viscosity of the glass when stirring ceases, and at present the time to cease stirring and cool rapidly is determined entirely by the temperature.

Experience shows that for each different glass there is a different temperature at which it is best to cease stirring and cool rapidly to the temperature where annealing may safely begin; also that for each type of glass, *i. e.*, flints, crowns, barium crowns, etc., this temperature represents apparently the same degree of viscosity. At present this temperature is located by simply trying melts at temperatures at which the glass has apparently the viscosity found best for that type of glass.

Actual measurement of the viscosity of the various glasses at the temperature stirring ceases would be very helpful in determining whether the viscosity of glasses of the same general type is the proper criterion to use in determining the rate of stirring as the cooling progresses and the point at which to cease stirring.

The practicability of measuring the temperature of the glass by placing a thermocouple within the stirring thimble is questionable because of the water-cooled thimble holder extending about six inches into the thimble and promoting a very considerable lag in temperature between the exterior of the thimble and the interior. The writer, however, has never actually determined the temperature of the glass in this manner.

BUREAU OF STANDARDS
WASHINGTON, D. C.

MR. R. J. MONTGOMERY: The use of the stirring machine, as a means of obtaining the viscosity of optical glass, is certainly of interest to all who manufacture this kind of glass. About a year ago, we tried to obtain some information on this subject, with the ordinary stirring machine. A wattmeter was placed on the circuit in an endeavor to obtain the variation of current used during the cooling period. We found that the power required to stir the glass as compared to the friction of the machine was so small that no variation could be detected between a furnace temperature of 2500 and 2000° F. We have also noticed that while stirring glass by hand and the power required varies very little with the temperature. This means that the forces involved are quite small and that a very sensitive apparatus would have to be con-

structed to obtain accurate readings. I am afraid that a machine of sufficient delicacy to give accurate readings would not be rugged enough to withstand handling by the labor ordinarily used around glass furnaces. The machines are often set at night with little competent supervision and exceptionally high-grade men would be required to take the necessary precautions to use a machine adequate for the work. A special test machine which would be set up and operated by laboratory men would certainly be of great value, and I hope that some day this will be done.

The use of a thermo-element inside of the stirring tube would also offer difficulties in practical operation. Occasionally the stirring tube breaks or cracks enough to allow the interior of the tube to fill with glass. Also it would be difficult to insert the water-cooled tube into the fire-clay stirring tube with a thermo-couple projecting from the end. The danger of breaking the protection tube of the couple would be great with ordinary glass plant labor.

I think the idea of temperature and viscosity measurement as given by Doctor Washburn could hardly be put into daily practice; but a test machine under proper supervision would be of great value in increasing our knowledge of certain properties of optical glass.

BAUSCH & LOMB OPTICAL CO.
ROCHESTER, NEW YORK

NOTICE.—*Further discussion of this subject is solicited. All communications should be sent to the Editor.*

THE MANUFACTURE AND USES OF ROLLED OPTICAL GLASS*

By H. S. Roberts and J. C. Hostetter

Introductory

In melting optical glass, the material in the pot is most nearly homogeneous immediately after the rapid stirring at the highest temperature; if the melt could now be quenched rapidly to the solid condition the maximum yield of good glass would be secured. It is obviously quite impossible to quench rapidly such a large mass of material of low thermal conductivity. However, this ideal condition may be approached by removing the pot from the furnace and pouring the glass on to a large iron table, just as is done in making plate glass, and, by following the other usual plate glass processes of subsequent handling we may pass rapidly from melt to finished product.

As a method for the manufacture of optical glass in quantity, the casting and rolling process possesses certain other advantages over the older method of cooling the glass in the pot. The same pot is used many times, with a tremendous saving in pots and pot-arching capacity. The glass may be made on a large scale in the usual plate glass furnace, with a melting schedule of 27 hours, or even less if Morey's[1] method of stirring during the fill is employed. The yield per pot is considerably increased over the ordinary method of setting the pots out to cool. Large sheets of optical glass may be secured by this means, in thicknesses up to $2^1/_2$ inches. The grinding and polishing necessary for critical examination can be done very quickly and cheaply. The large sheet may be cut readily with a wheel or diamond into rectangular blocks which are all within a small percentage of the same weight; consequently there is a much smaller loss to the user of such

* Received February 27, 1920.

[1] G. W. Morey, "A New Method of Optical Glass Manufacture," *J. Am. Ceram. Soc.*, **2**, 146–150 (1919).

glass than when the ordinary optical glass is chipped to a certain weight for pressing. Finally, rolled optical glass can reach the final inspection within a week from the time the pot is taken from the furnace. The decided advantages of rolling optical glass are immediately manifest to those who are familiar with the time-consuming processes of initial inspection and chipping, the pressing of blocks, their slow annealing, the mounting of small blocks previous to grinding and polishing, the delays involved in removing pressing defects, and the final pressing and annealing necessary to form the glass into well-shaped blocks for the user.

It may be mentioned here that the production of optical glass was relatively low at the beginning of 1918. The development of rolled optical glass about this time by the Bausch and Lomb Optical Company and the Pittsburgh Plate Glass Company (the latter had for some time previously been using this method in the manufacture of unstirred spectacle flint and crown) came when the production of large quantities of usable glass was vital. It may be said that the development of this process of handling optical glass was mainly responsible for securing to the military authorities the necessary additional quantities so badly needed at that time.

The method of manufacturing rolled optical glass is essentially a combination of the melting process for optical glass and the casting and subsequent processes for ordinary plate glass, with such refinements as are necessary to insure a sufficiently high quality in the finished glass. Consequently the earlier operations, batch mixing, burning and glazing the pot, filling in the batch, and fining, are exactly those employed for optical glass that is to be cooled in the pot. These operations have been completely described elsewhere[1] and will not be repeated here. During the cooling and stirring period, however, a somewhat different procedure is indicated, because the melt is expected to yield an entire pot of glass that is *reasonably* free from striae, whereas in the case of glass cooled in the pot a portion of the glass is expected to be *wholly* free from striae, the rest being rejected.

[1] C. N. Fenner, "The Technique of Optical Glass Melting," *J. Am. Ceram. Soc.*, **2**, 102–145 (1919). G. W. Morey, *op. cit.*

Cooling in the Furnace and Stirring

While the glass is hot, aluminous material is continually being dissolved from the pot, forming a layer, close to the pot wall, of viscous glass having an index of refraction different from that of the melt as a whole. Streamers of this material are carried, by convection and stirring, into the middle of the melt where they are gradually absorbed into the glass around them, the mixing process being accelerated by stirring. As the temperature falls, not only does the absorption of these streamers, or striae, proceed more slowly, but the increasing viscosity of the melt causes a greater tendency for them to be drawn into it by the movement of the stirring rod. As a result the average quality of the pot of glass as a whole deteriorates as the melt cools.

At the beginning of the stirring period the stirring rod is made to sweep rapidly over a circle nearly as large as the pot; as the cooling proceeds its speed is reduced and, if the glass is to be cooled in the pot, the diameter of the stirring circle is usually made less. This leaves the outer portion of the melt to cool without stirring and large quantities of ream unavoidably remain in it. When the melt is broken down this outer portion may be separated from the rest and rejected. Such a thorough separation is impossible in a rolled plate because of the unavoidable mixing that takes place as the glass is poured onto the casting table. Consequently the stirring should be carried on in such a way that the total amount of ream in the glass is a minimum. It has therefore been found better not to reduce the size of the stirring circle but to rely on stirring in a large circle at a low speed. Better results may undoubtedly be secured by the use of stirring machines that move the rod in a spiral rather than in a circle as is usually the case.

It is obvious that the melt is at its best in the early stages of cooling down from the fining period, and that the earlier thereafter it can be taken out of the pot, the fewer striae will be found in it. On the other hand, the glass must be sufficiently viscous, when it is poured on the casting table, to prevent it from splashing and foaming. It should consequently be cooled and stirred in the furnace until it has become sufficiently viscous. In this cooling process it is highly desirable to have the sides and bottom

of the pot lose heat faster than the top;[1] chilling the sides and bottom tends to cause the aluminous glass attached thereto to adhere to the pot in the casting which follows. If the pot is chilled rapidly from the top and if it should be cast while the bottom is still warm, the aluminous material from the pot is mixed more completely throughout the mass of metal in the subsequent rolling. Therefore, it is found desirable to keep a small flame playing across the top of the pot in the earlier stages of cooling, gradually cutting down the flame until the pot was removed from the furnace.

Casting and Rolling

The mechanical operations of casting and rolling are performed exactly as in making ordinary plate glass. The melt is poured out on an iron table and rolled into a sheet by passing a heavy roller over it, the thickness of the plate being determined by the thickness of the two steel strips on which the roller rides. As soon as the plate has become stiff enough to bear handling it is transferred, by sliding, into a heated kiln, which is then allowed to cool slowly to atmospheric temperature.

Considerable skill is involved in the operation of pouring and it has been found that workmen can be trained to pour the glass successfully at temperatures increasingly higher than that to which they have become accustomed. Temperatures at which certain glasses have been cast successfully are given in table 1.

TABLE 1—CASTING TEMPERATURES

Type of glass	n_D	Deg. F	Deg. C
Ordinary crown	1.52	2200	1205
Borosilicate crown	.515	2200	1205
Barium crown	.57	2150	1175
	.61	2200	1205
Ordinary flint	.575	2225	1220
	.616	2175	1190
	.65	2100	1150
Barium flint	.61	2150	1175

[1] The ideal condition which applies to the cooling of the melt whether it is to be set out or cast.

Cooling the Plate

The most desirable temperature for the kiln when the plate is placed in it varies somewhat with the kind of glass the plate is made of. It should be close to the "annealing temperature"[1] of the glass in question, and perhaps a little above it. Several of these annealing temperatures are given in table 2.

TABLE 2—ANNEALING TEMPERATURES[2]

Type of glass	n_D	Deg. F	Deg. C
Ordinary crown	1.52	1060	570
Borosilicate crown	.51	1095	590
Barium crown	.57	1080	580
	.61	1110	600
Ordinary flint	.57	870	465
	.61	850	455
	.65	835	445

After the kiln is filled it is sealed up and cooled, an operation requiring from 3 to 6 days. Usually the fire is shut off and the kiln cools naturally; but in the cooling of very thick plates it is often necessary to retard the cooling somewhat by maintaining a fire in the kiln for a day or two. The actual rate of cooling at any temperature should not exceed that which would be employed in the annealing muffle for blocks of the same material and thickness as the plate.[3] After the temperature has fallen below about 300° C (572° F) the cooling rate may be increased greatly without any danger of introducing permanent strain. It often happens that a faulty temperature distribution in the kiln causes plates to buckle or crack, even when the cooling rate has been sufficiently low to anneal them. In the theoretically perfect kiln the temperature over the whole of both surfaces should be the same at any instant. If one face is always warmer than the other, the differential contraction will cause the plate to buckle in such a way that the hotter face will become concave on cooling. This is because the glass has set while this difference of tempera-

[1] H. S. Roberts, "The Cooling of Optical Glass Melts," *J. Am. Ceram. Soc.*, **2**, 551 (1919).

[2] Taken from H. S. Roberts, *op. cit.*, p. 561.

[3] Data and directions for the annealing of blocks of glass are to be published soon by Adams and Williamson.

ture exists, and as the two faces approach the same temperature, the hotter surface becomes smaller than the other, and the plate must become dished to accommodate it. Cracking is usually caused by a horizontal temperature difference, whose distribution and magnitude depend on the heat insulation of the kiln. Here again the plate sets while there is a temperature drop through it and is strained by the differential contraction as this drop is equalized on cooling. The result is usually that the corners crack off, though in severe cases cracks may extend clear across the plate.

Either of these effects of faulty temperature distribution may be remedied by changing the insulation of the kiln until the distribution is sufficiently uniform. Cracks in the kiln itself have been known to admit cold air, with results that were very puzzling till the crack was discovered.

After it has cooled nearly to atmospheric temperature the plate is taken out of the kiln and the more obvious defects, such as pot stones and large bubbles, are cut out of it. Care is taken that the remainder shall consist of rectangular sheets suitable for bedding on the polishing table.

Polishing

The end to be attained by polishing optical glass is merely that the whole interior of each piece be plainly visible in order that the defective portions may be found easily. Therefore isolated scratches which would ruin a plate glass window need cause no concern, provided the surface is not cloudy, because the surface is practically always ground off when the glass is worked into a lens or prism. As in plate glass work, both sides are roughed with sand and emery and polished with rouge.

Examination

After being polished the plate is usually placed in a vertical frame near a window for examination. Both faces are cleaned with a cloth and the defective parts outlined on the surface of the plate with a crayon in order that they may be found readily and rejected when the plate is cut up. The usual rigid examination in parallel light may be made on the plate as a whole, pro-

vided that the apparatus is modified so that any portion of the plate may be placed between the two lenses.

After passing the above inspection, glass made in this manner may appear absolutely free from striae when examined through the flats, but still show some parallel layers when examined through the ends, although a certain proportion of the glass so made may show no striae at all, even when examined in the latter direction. It is obvious, therefore, that the uses of this kind of glass are somewhat restricted. In what follows, however, it will be shown that such glass is still usable for a great variety of purposes if a certain technique, which recognizes the presence of parallel striae, is followed in making the lenses or prisms from it.

The glass as it reaches the wareroom is sufficiently well annealed to permit of cutting into variously sized square blocks of such weight that one blank can be pressed from each. Or, if prisms are to be cut from the blocks, the size of the latter may be made such that a definite number can be cut from each, making due allowance for the width of the saw cut and the amount lost in grinding and polishing.

If the glass is to be pressed into blanks, it is ready to be turned over to the user as soon as it is cut up. If lenses or prisms are to be cut directly from it, the glass must, in most cases, be given a more careful annealing. This is done in the usual manner, with an annealing muffle.

Uses of Rolled Optical Glass

Because of the fact that rolled optical glass unavoidably contains a certain amount of parallel layers of glass differing in index from the main portion, it is necessary to take this factor into consideration when working up the glass into finished optical systems. The best results are secured when the path of the light is normal to the parallel layers. When the glass is used in this way, there is a slight decrease in transmission, but aside from this the glass is very little, if any, different in behavior from the ordinary optical glass. However, if used without regard to the presence of the parallel layers, difficulties may be encountered. The precautions to be taken when using rolled optical glass will be presented below. In this connection we may quote here

some results obtained by Lieut. Comdr. A. A. Michelson, at the Bureau of Standards, on the effect of striae.[1] He divided striae into two classes:

"First, those which appear, under proper conditions, as isolated bright streaks on the dark background, and, second, those in which such bright streaks are very numerous and run into one another forming bright but irregularly continuous bands. Even a superficial examination of the two kinds shows that the optical qualities of glass containing the first type are practically unaffected by the striae, while the latter specimens are *in general* unfitted for use in optical instruments." We may note here that striae in rolled optical glass which has been well stirred fall in Michelson's first class, and therefore his conclusions regarding this case apply in their entirety to rolled optical glass.

In regard to striae of the first class (which include those found in rolled optical glass), he concluded that: ". . . . isolated striae are of no more importance than are the bubbles found in some of the best telescope objectives. In case of striae of the second class this is not true in general, so that it is not desirable to attempt to utilize such glass for optical purposes where a high resolving power is required. Nevertheless, it is important to add that for many purposes, such as for binoculars, gun-sight telescopes, periscopes, etc., such glass may give excellent results if the planes of striation are *perpendicular to the line of sight.* Such glass should not be used for prisms."[2]

We may also quote here a foot-note from the same paper which is of interest in this connection: "A specimen of glass exceptionally badly striated when viewed end on was placed between collimator and observing telescope of the spectroscope (aperture 2 inches) which gives admirable definition. When the specimen was introduced with the striations perpendicular to the line of sight, no deterioration of the definition was observed. Hence a lens of such glass would perform quite as well as if the striation were not present."

[1] Bur. Standards, *Bull.* **15**, 41–45 (*Sci. Paper* **333**) (1919).

[2] Our conclusion in regard to prisms from such glass differs somewhat from his, but the difference is not irreconcilable if the prism is cut with respect to the direction of the striae, as will be shown.

Lenses.—Attempts to make lenses by cutting and grinding directly from the rolled sheets were not always successful. In

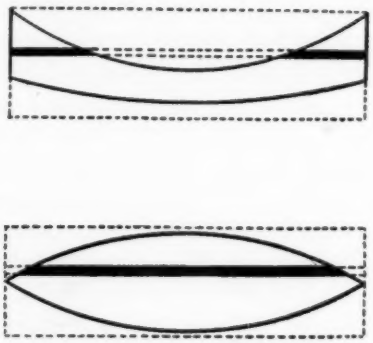

FIG. 1.—The manner in which layers of striae may cause concentric circles to appear in the finished lens.

one particular instance, finished lenses gave a field in which concentric rings appeared. This was especially true of the negative flint lens; similar trouble did not develop, at least not to such a large extent, in the case of the positive or crown element. At first this difficulty was thought to be caused by defective grinding and polishing, but later it was traced to the presence of heavy layers in the glass.[1] That such trouble might readily arise in this

FIG. 2.—The concentric circles of Fig. 1 may be avoided by pressing the glass into the shape of the lens.

manner is evidenced by the fact that in grinding out the negative lens from a block of glass the heavy layers, which are usually near the center of the plate, are cut across, whereas in the case of the positive lens, these layers are either not cut at all or, if cut,

[1] It should be stated here, however, that the rolled flint which was responsible for the trouble just described had never been intended for precision work, but was of the stock used regularly for bifocal lenses. The inspection which such glass received is, of course, much less severe than that given glass intended for precision instruments. Even so, the percentage of rejection for this cause was comparatively low.

the prism thus formed is near the edge of the field. Reference to figure 1 will make this clear.

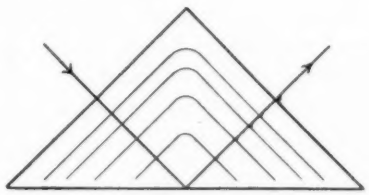

FIG. 3.—A telescope prism pressed from rolled glass. The light rays cross the films of striae at right angles.

The above-mentioned difficulties were overcome completely by pressing out the lens blanks, instead of cutting them directly from larger pieces. In this manner, the layers within the glass are curved in such a way that they are not cut in the finished lens, as will be seen by reference to figure 2 which shows the cross-section of a negative lens made in this manner.

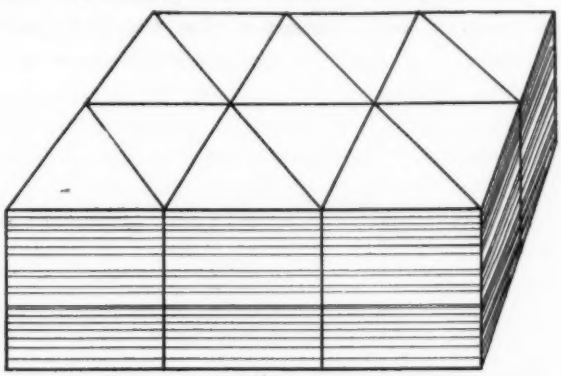

FIG. 4.—Prison blanks cut from rolled glass. Here the light rays are parallel to the striations.

Lens systems made up from rolled optical glass in this manner were found to make satisfactory low-power instruments such as single-unit sights, binoculars, and trench periscopes, but, considering the results obtained by such an authority as Professor Michelson, quoted above, it is quite obvious that rolled glass may also be suitable for high-power precision instruments.

Prisms.—In manufacturing prisms from rolled optical glass we must again take into consideration the fact that such glass may have parallel layers within it. Prisms may be made from this glass either by pressing or by cutting, but in the latter case we must know whether there is to be one reflection within the prism or two, and methods of cutting have been worked out in a fairly satisfactory manner for both classes.

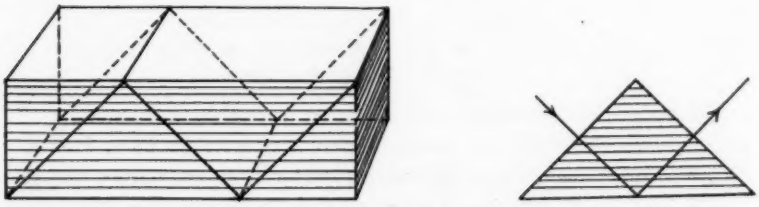

FIG. 5.—Taylor's method for cutting prism blanks, where there is to be but one reflection within the prism.

If the glass is to be pressed into prisms the parallel layers should be bent in such a manner that the light path is always normal to them. A battery commander telescope prism, that actually passed the government test when in the instrument, was pressed from rolled borosilicate in such a manner that when examined in parallel light the striae were bent as indicated in figure 3.

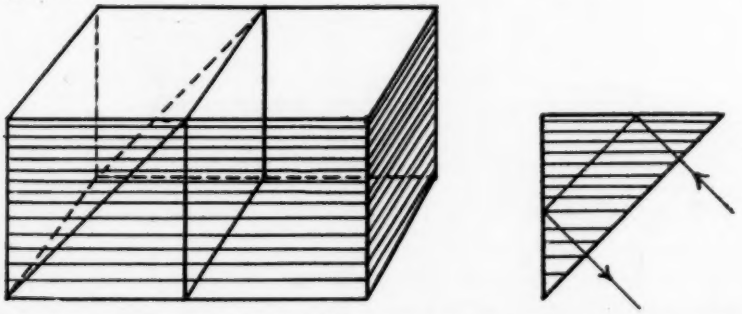

FIG. 6.—Taylor's method for cutting prism blanks, where there are to be two reflections within the prism.

In cutting prisms from rolled glass they may be sawed out as indicated in figure 4, and prisms cut in this manner were found to give a fairly satisfactory definition.

In addition to this method of cutting there is another method suggested by Mr. W. H. Taylor, of the Bureau of Standards, which yields a prism with the striae so arranged that the light path is always at 45 degrees to them. If there is only one reflection within the prism, as is the case for the periscope prism, the method of cutting is illustrated in figure 5; but if there are two reflections within the prism as in the case of the binocular prism, the method of cutting is indicated in figure 6. Both of these methods have worked out with some degree of success in practice.

Summary and Conclusions

Rolled optical glass is manufactured by a process that combines the stirring and earlier processes used for ordinary optical glass, with the casting and subsequent processes ordinarily used in the manufacture of rolled plate glass. The glass obtained is characterized by the presence of striae in the form of plane, parallel films, which are in general invisible unless viewed edgewise. Optical systems manufactured from rolled glass should therefore be designed so that the path of light rays cuts the striations in a direction that is as nearly as possible normal to the direction of the striations themselves.

The methods of manufacture and inspection are described and a discussion given of the manner of forming the glass into blanks for lenses and prisms.

This method lends itself admirably to large-scale manufacture of glass that is suitable for most of the optical instruments used in warfare, for photographic lenses, field glasses, spectacles and low-precision instruments in general. For instruments of the highest precision, recourse must still be had to the older process of cooling the glass in the pot.

GEOPHYSICAL LABORATORY
CARNEGIE INSTITUTION OF WASHINGTON
March, 1920

CERAMIC ABSTRACTS

General

The commercial synthesis of sillimanite. ANDREW MALINOVZKY. *Chem. and Met. Eng.*, **22**, 851 (1920).—A description of a cupola process for fusing alumina and silica to form sillimanite crystals. The reactions consist of forming carbides under reducing and combusting them under oxidizing conditions. (See *Jour. Amer. Ceram. Soc.*, **3**, 40–68 (1920).)

A. J. LAMBERT.

The potash deposits of Germany. STAFF ARTICLE. *Chem. and Met. Eng.*, **20**, 945 (1920).—The potash deposits of Germany have been estimated to contain about 2,000,000,000 metric tons of potash (K_2O), a quantity sufficient to supply the world for 2,000 years at the present rate of consumption. These beds have furnished practically the entire world's supply of potash for many years.

A. J. LAMBERT.

Diatomaceous or infusorial earth. W. C. PHALEN. *Chem. and Met. Eng.* **21**, 981 (1920).—Diatomaceous earth is more commonly known as infusorial earth, and is sometimes referred to by its German name "kieselguhr." It is also, though erroneously, called tripoli. It is composed of the siliceous remains of minute aquatic plants known as diatoms. In chemical composition, diatomaceous earth is a hydrous silica or opal, but as a rule it contains a considerable quantity of earthy impurities. The silica runs from 65 to 86 per cent in most samples. The chief impurity is clay. Deposits are found in many states, the most important being those in California.

A. J. LAMBERT.

Automatic apparatus for intermittent testing. G. W. VINAL AND L. M. RITCHIE. Bur. of Standards, *Tech. Paper* **171**.—This apparatus has been devised to meet the needs of the Bureau of Standards in making tests of dry cells and storage batteries, but is applicable to nearly any form of intermittent testing requiring the closing of electrical circuits at regular time intervals. The particular advantages of this type of apparatus for making these tests are: (1) Elimination of rapidly moving parts; (2) accuracy of the time intervals; (3) possibility of making a number of different tests simultaneously with the same apparatus.

R. N. BOORMAN.

The British china-clay industry. ANON. *Chem. and Met. Eng.*, **23**, 147 (1920).—The china-clay export trade of England is beginning to revive after the severe blow dealt it by the war. Of the total production of 964,000

tons in 1912 over 661,000 tons were exported. In 1918 the production dropped to 465,325 tons and the export to 232,464 tons. Last year the export rose to 286,543 tons. With the gradual return of freights to normal the regaining of the American market by British clay shippers seems only a matter of time. As the American market accounts for nearly half of the normal china-clay export trade of the United Kingdom, and was actually more than half in 1914, it is important to the British industry that this business be recovered. All the stocks of china-clay on the continent are practically exhausted, and the replacement of those stocks, apart from running supplies, must absorb large quantities in the very near future. R. N. BOORMAN.

PATENTS

Pug mill knife. FRED O. RUSH. U. S. 1,347,876, July 27, 1920. A pug mill knife comprising in combination a blade and separate shank, the shank having an irregular integrally formed portion for nonrotatively mounting the shank in the mill shaft, and means including a plurality of members arranged at substantially the same distance from the axis of the shaft for securing the blade to the shank.

Apparatus for treating silicates. WALTER GLAESER. U. S. 1,347,024, July 20, 1920. The combination of a stationary furnace chamber, a stationary stack chamber spaced therefrom, a rotary tubular shell connecting and affording communication between the chambers, a kiln mounted in the shell and extending through the chambers and projecting beyond the front wall of the furnace chamber, and receiving means associated with the projecting end of the kiln beyond the wall of the furnace chamber.

Tunnel kiln. PAUL A. MEEHAN. U. S. 1,348,510, August 3, 1920. In a kiln the combination with a kiln chamber having a ware inlet and egress port and means for maintaining a high temperature zone displaced longitudinally of the kiln from the port, of a carrier adapted to reciprocate in the kiln to alternately carry ware back and forth between the port and the zone.

Tunnel kiln. PAUL A. MEEHAN. U. S. 1,348,511, August 3, 1920. A combustion chamber structure for kiln heating provided at one end with air and fuel inlets and an outlet for products of combustion, and formed internally with two passages or chambers extending longitudinally of the structure and communicating, one with said inlets and the other with the outlets at the one end of the structure, and in communication with one another at the opposite end of the structure.

Drier. GUILFORD L. SPENCER. U. S. 1,348,757, August 3, 1920. A dryer, including a casing, a housing positioned below such casing, a tube extending from the lower end of the casing and terminating adjacent the top of the same and communicating at its lower end with the housing, a partition

dividing the casing into an upper and a lower compartment, the partition being formed with openings, capsules positioned within such openings, and a source of suction connected to the lower of these compartments, the capsules seating against the opening in the partition in such a manner as to form an air-tight joint.

Smelting furnace and the like. JAMES GAUNT. U. S. 1,344,878, June 29, 1920. This furnace has a cylindrical casing open at its upper and lower ends and provided on the inner side of its wall with vertical, radially disposed spaced ribs; a cover on upper end of the casing, a hopper mounted on the cover; a grate, grate-supporting means with which the lower end of the casing is provided; a refractory lining in the casing supported also on the grate-supporting means and co-acting with said spaced ribs to form a circuitous air conduit around the lining and to a point below the grate; an air blast pipe connected to the casing, a crucible mounted on the center of the grate and a detachable closure being hollowed in its upper side and hence forming a chamber to conduct the air blast from the conduit to air spaces in the grate.

Mechanical Mixer and Drier. HUDSON H. BUBAR. U. S. 1,344,675, June 29, 1920. An apparatus comprising a container having a bottom provided with a contralongitudinal arc-shaped channel and channels disposed parallel therewith on opposite sides thereof, a rotary shaft carrying spiral blades disposed over the central channel and rotary shafts carrying spiral blades disposed over the side channels, and a mean for rotating the central shaft in a direction opposite to the rotation of the side shafts, the path of blades of the central shaft interlapping with the paths of blades of the side shafts.

Method of Deflocculating Solid Substances. EDWARD GOODRICH ACHESON. U. S. 1,345,306, June 29, 1920. A method of deflocculating graphite, consisting in subjecting the same, mixed with a deflocculating agent and in paste form, to a process of attrition, the total moisture contents of charge being less than 32 per cent by weight.

Furnace. JOSEPH H. ROACH. U. S. 1 346,464, July 13, 1920. A grate for forced draft furnaces comprising a plurality of reciprocatably mounted grate bars, a partition dividing the supporting structure into separate air intake conduits, co-acting members carried by the bars forming a constricted passage by way of the bar structure between the conduits, and means to reciprocate the bars without interfering with the constricted passages.

Furnace construction. JOSEPH F. TUTEIN. U. S. 1,345,652, July 6, 1920. This describes furnace structure, the combination, with a furnace chamber, a mechanical fuel feed, and a speed-changing device applied to the fuel feed, of an automatic control for the speed-changing device including a movable element subject in opposite directions to furnace-chamber pressure and to atmospheric pressure.

C. M. SAEGER.

Refractories

Binders for ceramic colors. ANON. *Keram. Rundschau*, **28**, 239 (1920).—The following materials are suggested as substitutes for sugar in ceramic colors: glycerine, dextrine, gum tragacanth, gum arabic, fine white clay, and Na_2SiO_3. The above materials are mixed with a coloring oxide mixt. containing considerable flux such as feldspar or glaze. A special binder used for underglaze colors is prepared by boiling thoroughly a mixt. of garlic and onions and filtering off the liquid. This liquid is then mixed with the coloring oxides and since it does not combine with the glaze leaves sharp lines in the design. H. G. SCHURECHT.

Firing kilns with wood. ANON. *Sprechsaal*, **53**, 252 (1920).—Owing to the coal shortage, the use of wood in place of coal is becoming necessary. One source of supply is tree stumps which may be removed by blasting, with a machine and by hand. Stumps removed by blasting contain considerable sand and dirt and are not as desirable as the cleaner product removed by hand. Roots as a rule are unfit for firing kilns. The wood is cut in 1 m. lengths and the thickness is about 8–10 cm. Sound wood gives good results in firing, comparing favorably with brown coal. H. G. SCHURECHT.

Refractories for glass furnaces and melting walls. J. BALDERMANN. *Tonind. Ztg.*, **44**, 581–82, 612 (1920).—Grog should never be greater than 3 mm. and should be fired high enough to remove all of the shrinkage. Often coarse quartz is added to glass refractories which is poor practice since these particles are dissolved by the glass, leaving a honeycombed effect. Old pots make excellent grog since all of the shrinkage has been burned out.
H. G. SCHURECHT.

Light weight refractories. ANON. *Tonind. Ztg.*, **44**, 718 (1920).—Good insulators for furnaces have for some time been made by adding sawdust, coal and kieselguhr to clay and firing same. In Asia Minor there is a type of kieselguhr which has sufficient strength so that it may be sawed and cut into brick. Such brick need not be fired. It is suggested that this material would make excellent insulation for buildings. H. G. SCHURECHT.

Furnace linings with magnesium hydroxide. ANON. *Keram. Rundschau*, **28**, 260 (1920).—Magnesite brick may be made by using 10–15 per cent $Mg(OH)_2$ with dead burned magnesite. Brick are pressed with a pressure equal to 800 atms. To prevent cracks the brick should be kept damp and dried slowly. Brick should be laid with close joints using 90–92 parts dead burned magnesite and 10–8 parts of coal tar as a binder.
H. G. SCHURECHT.

Investigations on zirconium. J. W. MARDEN AND M. N. RICH. *Jour. Ind. & Eng. Chem.*, **12**, 651–656 (1920).—The most satisfactory method of producing

nearly pure ZrO_2 was as follows: One pound or a larger quantity of ore was slowly heated with four parts of concentrated H_2SO_4 until free of fumes and the temperature gradually raised to 650° C. After cooling the flour-like residue was extracted with 50 parts of cold water, filtered, and sodium carbonate added to neutralize any free acid until the zirconium hydroxide just began to form. The solution was allowed to stand 3 or 4 days, during which time the basic sulfate $4ZrO_2.3SO_3.14H_2O$ gradually separated out. When this was ignited a very high-grade ZrO_2 was obtained, which in one case contained 99.84 per cent ZrO_2 and was free from any determinable trace of SiO_2. Exclusive of labor and equipment the cost for the production of 1 lb. of oxide by this method was about twenty cents. Data are given also on the preparation of pure K_2ZrF_6, the preparation and properties of zirconium metal, and the methods for analysis of zirconium ores. R. N. BOORMAN.

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Refractory article and method of making the same. SILAS C. LINBARGER. U. S. 1,345,377, July 6, 1920. This describes a refractory article having a body portion consisting substantially of fire-clay, a facing portion containing a substantial portion of silicon carbide, and an intermediate portion containing silicon carbide in such decreasing amounts from the facing portion as will give a graduated and increasing coefficient of expansion from the facing portion to the body portion.

Light-weight refractory brick. ROSS C. PURDY AND MILTON F. BEECHER. U. S. 1,345,632, July 6, 1920. A composition of matter for a porous brick, comprising a burned refractory lignite clay mass.

Boiler arch and wall and means for supporting same. LUTHER S. SHAW. U. S. 1,345,410, July 6, 1920. This describes a setting made with the combination of a plurality of beams suitably supported, a plurality of bolts suspended from the beams fitted with relatively large disks or nuts for supporting an arch or wall, a platform for temporarily supporting an arch or wall of unburned fire-brick material, a plurality of bolts detachably connected with the first-named bolts by the disks for suspending the platform during the process of burning the fire-brick material, an arch or wall suspended from the first-named bolts, formed of unburned fire-brick material upon the platform and baked while temporarily supported thereby. C. M. SAEGER.

Glass

Science and the glass industry. C. H. KERR. *Chem. Eng.*, **28**, 107–11 (1920).—While the developments along mechanical lines, especially in automatic machinery, has been marvelous, there has not been a corresponding application of scientific knowledge. However, the importance of the science of glass making is now being more fully appreciated and a real evolution has started. Better fundamental knowledge is now available to help such progress. C. H. KERR.

Chemical glassware, the resistant properties of. (*a*) **The resistant properties of some types of foreign glassware.** J. D. CAUWOOD AND W. E. S. TURNER. *J. Soc. Glass Tech.*, **2**, 219–35 (1918).—B. **Further investigation on chemical glassware.** CONSTANCE M. M. MUIRHEAD AND W. E. S. TURNER. *J. Soc. Glass Tech.*, **3**, 129–31 (1919).—The tables on pages 418 and 419 of this volume of the JOURNAL belong with the abstract given on page 420 under the above title. EDITOR.

Progress in optical glass manufacture. ANON. *Chem. and Met. Eng.*, **23**, 158 (1920).—A triumph of American ingenuity is the manufacture of optical glass. Prior to the war practically all this material was produced abroad. Lenses up to 20 in. in diameter are now made in this country and larger ones contemplated. R. N. BOORMAN.

Composition of hollow glassware for tanks. *Schnurpfeil's Review for Glass Works*, **4**, 613.—Sand, 1,000 lbs., soda ash, 320 lbs., lime, 200 lbs., saltpetre 10 lbs., cullet 200 lbs., nickel oxide $^1/_8$ oz. R. J. MONTGOMERY.

Composition of glass for tumblers. *Schnurpfeil's Review for Glass Works*, **4**, 633.—Sand 1,000, soda ash 330, lime 160, barytes 80, saltpetre 25, arsenic 3, manganese 1. R. J. MONTGOMERY.

Composition of glass for pressed ware. *Schnurpfeil's Review for Glass Works*, **4**, 633.—Sand 100 lbs., soda ash 33 lbs., barytes 15 lbs., lime 12 lbs., saltpetre 3 lbs., arsenic 8 oz., manganese 3 oz. R. J. MONTGOMERY.

Composition of glass with the appearance of mother-of-pearl. *Schnurpfeil's Review for Glass Works*, **4**, 581.—Sand 100, soda ash 25, lead 15, nitrate of potash 25, cryolite $1^1/_2$, bone ash 5, borax 25, nitrate of bismuth 3, nitrate of copper $^1/_4$, fluorspar $1^1/_2$. R. J. MONTGOMERY.

Composition of glass for electric lamp bulbs. *Schnurpfeil's Review for Glass Works*, **4**, 583.—Sand 100, lead 36, lime 8, soda ash 30, nitrate of potash 3, borax 1. R. J. MONTGOMERY.

Composition of watch glass. *Schnurpfeil's Review for Glass Works*, **4**, 583.—Sand 100, lime 15, soda ash 33, nitrate of potash 5, lead 5, arsenic $^1/_2$, manganese $^1/_4$, antimony $^1/_4$. R. J. MONTGOMERY.

Composition of opal glass for illuminating glassware. *Schnurpfeil's Review for Glass Works*, **4**, 599.—Sand 100, soda ash 30, fluorspar 20, feldspar 35, cryolite 8, manganese $^1/_4$. R. J. MONTGOMERY.

Analysis of a Bohemian cut glass. *Schnurpfeil's Review for Glass Works*, **4**, 613.—SiO_2 70.16, Al_2O_3 1.01, CaO 12.11, MgO 0.39, K_2O 14.98, Na_2O 2.03. R. J. MONTGOMERY.

Composition of green lead glass without potash. *Schnurpfeil's Review for Glass Works*, **4**, 615.—Sand 100 lbs., soda ash 30 lbs., saltpetre 5 lbs., lead 48 lbs., red bichromate of potash 19 oz., copper oxide 6 oz., iron oxide 4 oz. R. J. MONTGOMERY.

Composition of glass for vacuum bottles. *Schnurpfeil's Review for Glass Works*, **4**, 615.—Sand 100, soda ash 36, borax 4, alumina 4, lime 20, saltpetre 2. R. J. MONTGOMERY.

The importance of sulphate of soda in the glass industry during the war. *Schnurpfeil's Review for Glass Works*, **4**, 625.—The substitution of soda for potash caused considerable trouble. The use of sulphate of soda gives a glass of poorer quality. The iron content is 0.01 to 0.08 per cent, which is higher than that of the carbonates of soda or potash. Sulphate made in lead pans is freer from iron than that made in iron ones. The salt cake batch attacks the pot more and is more difficult to melt. 4 lbs. of powdered anthracite or charcoal are used for 80 lbs. of sulphate of soda. The correct amount is important. R. J. MONTGOMERY.

Composition of brown glass. *Schnurpfeil's Review for Glass Works*, **4**, 631.—Sand 100, soda ash 33, fluorspar 2, lime 20, graphite 4 to 5, manganese $1^1/_4$. R. J. MONTGOMERY.

Composition of thermometer glass. *Schnurpfeil's Review for Glass Works*, **4**, 633.—Sand 100, soda ash 36, lime 20, zinc oxide 10, alumina 6, borax 6. R. J. MONTGOMERY.

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Method and apparatus for the manufacture of pressed sheet glass products. FRANK L. O. WADSWORTH. U. S. 1,346,571, July 13, 1920. The method of manufacturing pressed glass sheets or plates which comprises the preliminary spreading of the molten material to sheet form, the subsequent reheating of one side of spread sheet to a substantially uniform temperature over the entire area to be subjected to pressing operations and the final pressing of the reheated surface. The apparatus for the manufacture of pressed glass plates or sheets which comprises a glass receiving table, a spreading mechanism, a furnace, a press mechanism and means for moving the table relatively to the other element.

Glass furnace. JOHN R. SCOHY. U. S. 1,347,181, July 20, 1920. A glass furnace having floaters and pockets formed in vicinity of and in advance to the outer end of the floaters for collecting scum held back by the floaters.

Glass molding machine. HENRY O. BISBING. U. S. 1,347,202, July 20, 1920. The combination of a molten glass reservoir, a discharge passageway for such reservoir, a chain-like series of glass receptacles adapted to be brought underneath such discharge passageway, and inclosure for the run-way of such chain-like series of glass receptacles and means for directing a hot blast through the roof of such inclosure against the discharging stream of molten glass.

Apparatus for testing lenses. FRANK TWYMAN. U. S. 1,347,133, July 20, 1920. An apparatus for testing a lens comprising a plane parallel glass plate partially silvered and adapted to reflect part of a beam of light and to transmit a part, two mirrors adapted to reflect the light back to the plate and mounted so that their distances from the plate can be varied, a carriage adapted to adjustably receive the lens to be tested and maintain the same in the path of light to and from one of the mirrors, means for removing the lens on the carriage both along and at right angles to its optical axis and means for turning the carriage about an axis at right angles to the end optical axis of the lens.

Apparatus for drawing glass cylinders. LAWRENCE EDWIN STEWART. U. S. 1,347,131, July 20, 1920. The combination with hoisting means, a fan and an electric motor for the fan, of an electric circuit including the motor, a rheostat operable automatically by the hoisting means, a manually operable rheostat, the rheostats being included in series in the motor circuit, a switch for excluding a portion of the resistance elements of the rheostats from the motor circuit.

Glass forming machine. RICHARD LA FRANCE. U. S. 1,348,365, August 3, 1920. The combination with a finishing mould, of a holding device to engage an article in the mould and hold it during the opening of the mould, a piston motor and means operated and controlled thereby to move the holding device laterally to a position over the article during a portion of the piston stroke and downward into engagement with the article during another portion of the stroke.

Imitation-beveled-glass panel. JOHN A. MCAVOY. U. S. 1,345,792, July 6, 1920. This covers a glass panel having for simulating a bevel, a groove parallel to the margin and endless within the face of the panel, the groove being only to sufficient depth to cause refraction of light at the lines which it occupies.

Means for making sheet-glass. MICHAEL J. OWENS. U. S. 1,345,629, July 6, 1920. The combination with means for drawing a sheet of glass, of a bending roll over which the glass is drawn, and a flattening device moving over the surface of the glass in a direction lengthwise thereof.

Making sheet-glass. MICHAEL J. OWENS. U. S. 1,345,628, July 6, 1920. The combination with means for drawing a sheet of glass, of a bending roll over which the glass is drawn, and a flattening device moving transversely over the surface of the glass after it passes beyond the bending roll.

The method, which consists in continuously drawing a sheet of glass from a pool of molten glass over a support, cooling the sheet before it reaches the support and thereby causing a surface glaze to form thereon which will not

be marred by its contact with the support, and sliding a flattening device over the surface beyond the support, thereby flattening the sheet.

Sand-drying plant. HENRY W. NAGLE. U. S. 1,346,238, July 13, 1920. A sand plant comprising a sand bin having an opening through which the sand is adapted to flow by gravity, a gate for controlling the opening, spaced heating elements between and over which the sand is adapted to pass after leaving the bin, each of the elements having portions having different inclinations, the inclinations being steepest where the sand first flows and is wettest, and less steep at the points to which it passes after being partially dried, an inclined screen for shifting the sand as it leaves the heating elements, and a chute and hopper for receiving the shifted sand.

Lens-grinding machine. EDGAR D. TILLYER AND LUCIAN W. BUGBEE. U. S. 1,347,766, July 27, 1920. A lens-grinding machine, including a frame, a rotating table bearing an annular grinding tool, the tool having a main spherical transverse curve and a supplemental transverse portion of different curve, a main drive gear carried by the frame, a plurality of spindles having pinions at their upper ends to mesh with the drive gear, and a plurality of lenses at their lower ends for engagement with the tool, whereby a pair of surfaces of different fuel will be formed on each of the lenses, and means for independently shifting the spindles to move their pinions out of the mesh with the main drive gear. C. M. SAEGER.

Whiteware and Porcelain

Casting of porcelain. ANON. *Sprechsaal*, **53**, 228 (1920).—In many cases it was found impossible to get rid of bubbles in casting porcelain unless the mold was first coated with slip before casting. Bubbles are due to inferior kaolin, wet molds, wrong water content, which should be neither too low or too high, and to improper pouring. Air bubbles may be removed from the slip by jarring the mold after casting or by stirring violently with a stick before all of the slip has been added. In pouring, the slip should be thrown against one side of the mold, thus preventing the entrapping of air. All plaster should be screened in making a mold, thus preventing lumps of unequal density. H. G. SCHURECHT.

Porcelain doll heads. ANON. *Sprechsaal*, **53**, 306 (1920).—Doll heads are cast, and when leather hard the eyes and mouth are cut out. A suitable body consists of 30 kaolin, 40 feldspar and 30 flint. This body is ground 90 hrs. with 2 per cent soda. If it is desired to glaze the heads, the body should only be ground 24 hrs., as longer grinding tends to craze the glaze. A glaze maturing at cones 8–9 consists of 28.76 feldspar, 9.52 dolomite, 10.35 whiting, 17.23 calcined kaolin and 34.14 quartz. H. G. SCHURECHT.

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Process and apparatus for molding clay products. DAVIS BROWN. U. S. 1,347,484, July 20, 1920. Apparatus for forming clay articles, comprising a mould receiving table, a power actuated cylinder in alignment with the table, jolt ramming mechanism having a vertically removable table normally at rest and in alignment with the mould receiving table, a hopper carried by the vertically reciprocating table and spaced therefrom, and automatic means to actuate the power cylinder and jolt ramming mechanism, whereby an empty mould applied to the mould receiving table will be forced under the hopper and thereupon subjected to jolt ramming action with the hopper to fill the mould, the action of the cylinder forcing the mould into position, being automatically retracted to receive the second empty mould, and the successive action of the cylinder removing the filled mould and positioning the second empty mould under the hopper.

Clay turning machine. LILLIAN L. RANDALL AND EDWARD A. FRIES. U. S. 1,348,580, August 3, 1920. A machine for turning plastic material comprising a tube adapted to have an elongate rod of plastic material fed therethrough, the tube being arranged closely to confine the rod of plastic material throughout the entire length of the rod, means that the forward end of the tube yielding to grip the rod throughout an extensive area, a tool in operative relationship to the end of the rod projecting from the forward end of the tube, and means for producing relative angular motion between the tube and the tool to cause the tool to operate upon the rod. The method of forming tubular articles from plastic material comprising rotating a blank of the plastic material, boring the blank along its axis of rotation, and turning the exterior of the blank while the boring tool is extended thereinto, the plastic blank being supported by the boring tool while being turned.

C. M. SAEGER.

Enamels

Enamels for sheet iron and steel. J. B. SHAW. Bur. of Standards, *Tech. Paper* 165.—This is a general treatise dealing with the technology of enameling sheet iron and steel. It has been prepared to answer the demand for a treatise dealing with the technology of the manufacture of vitreous enamels for these metals. This subject is not treated adequately in any existing publication. In collecting data for this paper an effort was made to obtain reliable and authentic information wherever available and to correlate it in such a manner as to shed some light on the problems encountered by enamelers. The treatise is a complication of data dealing with the subject of enameling from various publications, from the notebook of the author, from the files of the Bureau, and from the experience of men engaged in the enameling industry in this country. Among the subjects dealt with in connection with the properties and preparation of steel for enameling are physical and chemical requirements, sand blasting, treatment preliminary to pickling and methods of

pickling. A chapter is devoted to the properties of the raw materials used in compounding enamels. The relations between chemical composition and physical properties of enamels are discussed fully. The procedure used in the preparation, applying and firing enamels are described in detail. The calculation of enamel formulas is fully explained and examples are given. The physical properties of enamels are dealt with in some detail and resistance of enamels to chemical action is fully discussed. R. N. BOORMAN.

Composition of blue enamel for cast iron. *Schnurpfeil's Review for Glass Works*, **4**, 613.—Feldspar 34, borax 21, soda ash 13, fluorspar $5^1/_2$, saltpetre 2, cobalt oxide $1^1/_2$. R. J. MONTGOMERY.

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Coating apparatus. LAWRENCE R. DAVIS. U. S. 1,347,256, July 20, 1920. A combination with a spraying device, of a series of carriers for the articles to be coated, means for successfully moving the carriers into register with the spraying device, and controlling means for the spraying device adapted to automatically shut off the spray prior to the movement of a carrier into register therewith, with controlling means comprising a drive shaft for the carrier-operating means, a sleeve valve carried by the drive shaft at one end thereof, a casing for the valve, and a conduit affording communications between the valve and the spraying device.

Method and apparatus for coating or enameling metal. JOHN S. JOBE. U. S. 1,348,361, August 3, 1920. In the art of coating metal castings, the method which consists in supporting the casting to be coated in an inclined position with one of its surfaces exposed to coating operations, coating such surface, and then turning the casting into a reverse inclined position to expose its other surface without removing it from its support and coating the other surface, substantially as described.

Crane hinge for muffle furnace doors. GEORGE W. LINDSAY. U. S. 1,346,903, July 20, 1920. A mounting for muffle furnace doors comprising in combination with the furnace and its door, a crane hingedly mounted at one end on the furnace and having a swivel connection at its other end with the door of the crane portion of the swivel connection being positioned above the door, whereby the door may be swung out beneath the crane.
C. M. SAEGER.

Brick and Tile

Non-plastic material for brick. ANON. *Tonind. Ztg.*, **44**, 689 (1920).—In most cases sand is used to reduce the shrinkage of clay brick when this is necessary. Ground brick bats make an excellent substitute for sand, since the brick do not crack as easily and dry faster than those in which sand is used. When ground brick bats are used they should be burned hard as soft

burned bats may cause scumming. In a few cases cinders are used as a non-plastic but it is necessary to select those free from soluble salts.

H. G. SCHURECHT.

Loam press brick. WALIGORSKI AND CARRIERE. *Le Ciment*, **25**, 54 (1920) *Tonind. Ztg.*, **44**, 644 (1920).—Brick were made with a pressure of 200–400 kg. per sq. cm. The loam used contained 5–10 per cent clay and it was found that those containing the most clay were the strongest. The brick should have a crushing strength of at least 50 kg. per sq. cm. Since the brick are readily disintegrated with water, investigations are now under way to develop a covering which will protect the brick from the rain.

H. G. SCHURECHT.

Brick sand. H. SACHSE. *Tonind. Ztg.*, **44**, 718 (1920).—In *Tonind. Ztg.*, **55**, 529, the author calculates the amt. of sand present in brick clays from their chem. analyses which is incorrect. A more accurate way is by rational and mechanical analysis. In comparing both methods the following results were obtained for free silica:

Calculated from chem. analysis	32.80	35.80	41.00	43.20	49.90	57.80	72.18
From mechanical and rational analysis.....	39.72	40.96	42.64	50.39	58.80	50.64 quartz and 19.37 mineral particles.	67.03 quartz and 0.45 mineral particles.

It is important to know whether the silica is present as fine or free silica or combined silica, since it is necessary to burn clays containing fine or combined silica to a higher temp. than those containing coarse or free silica.

H. G. SCHURECHT.

Street paving with sand lime brick. H. JOLIG. *Tonind. Ztg.*, **44**, 703 (1920).—The fact that some sand lime brick have a crushing strength of 320 kg. per sq. cm. led to experiments in using sand lime brick for pavements and sidewalks. After 10 yrs. service the streets made of sand lime brick were in excellent condition, whereas roads made of natural rock and ballast failed in this period. This pavement was situated near the front and received severe traffic. During this period, 10–20 mm. was worn from the surface of the brick and it was predicted that this road would stand 10–15 yrs. more service. The brick are 65 × 140 × 290 mm. and are made of clean, fine sand and 11 per cent lime. These pavements are supported on either side by cement curbing, the pavement forming an arch between the curbings. The spaces between the brick are about 5 mm. which are filled up with fine sand. For sidewalks they are much more attractive than clay brick and do not become slippery in wet weather. H. G. SCHURECHT.

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Brick machine. HAROLD H. GOE. U. S. 1,344,880, June 29, 1920. This machine is for making taper brick, the combinations of an upper die having an inclined surface to produce the taper, a lower die, a die box and yielding means in the die construction and arranged to effect, prior to compression, a graded distribution of the material in the die box substantially in accordance with the taper of the brick to be formed and to assume, during compression, a position which does not interfere with the formation of the brick.

C. M. SAEGER.

Cement and Lime

Quicklime and milk of lime. B. KOSMANN. *Tonind. Ztg.*, **44**, 555 (1920). —Lime upon slaking continues to take up H_2O until some of it contains 8 mols. of water. Lime tetrahydrate is probably the hydrate which contains all chemically combined H_2O, whereas those containing more than 4 mols. are combined with water partly mechanically. Lime tetrahydrate is known as the hydrogel of lime and is colloidal in nature, being slippery and remaining in suspension in water for long periods. The sp. gr. of some of the hydrates are as follows: $Ca(OH)_2$ = 2.236, $H_3Ca(OH)_5$ = 1.345, and $H_7Ca(OH)_9$ = 1.198 — 1.224.

H. G. SCHURECHT.

Cement substitutes. C. PLATZMANN. *Tonind. Ztg.*, **44**, 697–699 (1920). —The big demand for cement has led to the manuf. of many substitutes. Those known as "Vulkancement," "Montanzement" and "Refractory Cement" are unfit for building purposes. A new cement known as "Cementin" has been put on the market. The strength of this cement after storage for 28 days is only 58.1 kg. per sq. cm., whereas that of Portland cement is 345 kg. per sq. cm. "Silikalit," another cement substitute, was found to compare closely to Portland cement. This is supposed to be a ground hydraulic lime. Hydraulic lime may be produced by grinding lime with blast furnace slag or phonolite. The principal reactions are the formation of silicate which upon setting form a bond. It is suggested that volcanic slag be used together with cements thus decreasing the amt. of cement necessary.

H. G. SCHURECHT.

The effect of acids on concrete. ANON. *Sprechsaal*, **44**, 573 (1920).— It is repeatedly stated in literature that cements are resistant to dilute acids. It is well known that cements are not resistant to carbonic acid and for this reason must be protected with a covering of asphalt. W. Petry (Der Bauingenieur **1**, 12 (1920)) states that the action of those acids which form soluble salts with lime are more destructive to cements than those which form insoluble compounds with lime as sulphuric acid. Contrary to this statement it is known that sulphuric acid is harmful to cements. P. also states that acid solutions containing less than $^1/_{10}$ acid are harmless which must also be denied.

H. G. SCHURECHT.

Destruction of cement pipes and mortar. A. SPLITTGERBER. *Wasser und Gas*, **17**, (1920); *Tonind. Ztg.*, **44**, 719–20 (1920).—Among destructive agencies are acids and sulphur. These may be present in the soil, in ground waters, in the air and from materials used in building construction. To prevent destruction, the cement should be made water-tight, which may be done by the addition of substances which combine chemically with the cement, or by the application of a protective coating such as asphalt, or brick masonry. The article contains a bibliography of literature on this subject.

H. G. SCHURECHT.

The setting of calcium sulphate cements. C. L. HADDON. *Jour. Soc. Chem. Ind.*, **39**, 165T.—Plaster of Paris forms a weak cement because of the large excess of water, and hence the smaller percentage of cement. The crystals are also much finer grained than with any other calcium sulphate cement. Neat calcium sulphate cement must be kept damp to ensure complete hydration. This is not necessary if a sulphate solution (Cu, Fe″, Fe‴, ammonium, Al) is added; a 3–5 per cent solution mixed to a thick paste gives the best cement. Contrary to Rohland's theory, sulphates exert a marked accelerating effect on setting. With 5 per cent or stronger sulphate solutions a peculiar drop occurs in the tensile strength after the first day and the cement subsequently becomes stronger on drying.

R. N. BOORMAN.

Measurement of plasticity of mortars and plasters. WARREN E. EMLEY. Bur. of Standards, *Tech. Paper* **169**.—An instrument has been devised whereby the work done in spreading a plaster on a wall can be measured. A sample of the plaster is molded into cylindrical form on a porous plate. It is then pressed with a continuous screw motion against a stationary conical disk. The forces transmitted through the sample to this disk are measured. The porous base-plate acts as the undercoat on a wall to suck the water out of the sample; the disk acts as a trowel to spread the sample over the base-plate. The instrument enables one to measure the rate of drying of the plaster, the force required to spread it, and the thinness to which it can be spread. A proper correlation of these three factors leads to a definite expression of the degree of plasticity of the material. R. N. BOORMAN.

Recommended specifications for quicklime and hydrated lime for use in the cooking of rags for the manufacture of paper. Bur. of Standards, *Circ.* **96**.—This is the first of a series of specifications for the lime used in various chemical industries. The new specification is based on a draft originally prepared at the Bureau of Standards. To assist in perfecting the specification, the Bureau of Standards called an interdepartmental conference of representatives of several bureaus most concerned. As revised, the specification has the unanimous approval of those concerned, including the National Lime Association and the Technical Association of the Pulp and

Paper Industry. In addition to giving the percentage maxima or minima of the significant constituents, detailed regulations are given for the packing and marking, and careful directions for the analytical methods used.

R. N. BOORMAN.

PATENTS

Plaster board. LEWIS E. ARMSTRONG AND HUGH BOWYER BROCKENBROUGH. U. S. 1,347,487, July 27, 1920. A plaster board comprising a body of plastic material, a sheet of fibrous material covering one face of the body and having a marginal portion engaging an edge of the body and adapted to be folded over upon the opposite face of the body, a sheet of fibrous material covering the opposite face of the body and in lapping engagement with the folded-over marginal portion of the first-mentioned sheet, the latter having portions thereof removed to permit the material of the body to pass through the underlapping marginal portion and to adhere to the folded-over marginal portion.

Art of making plaster board. MORGAN K. ARMSTRONG. U. S. 1,348,387, August 3, 1920. The process consists of advancing a bottom sheet of fibrous material, of superposing thereon a plastic mixture to form the body of the board, of confining the plastic mix in such a manner on the bottom sheet as to leave marginal parts of the sheet exposed at each side of the same beyond the intended width of the plaster board, of superposing a narrower top sheet of fibrous material on the plastic mix and at the same time spreading the plastic mix evenly over the bottom sheet to the intended thickness of the board, of turning over the projecting marginal parts of the bottom sheet to overlap the marginal parts of the top sheet, first spreading on the projecting parts a small amount of plaster so that the small amount is turned over with the projecting marginal parts of the bottom sheet upon the marginal parts of the top sheet, the turning-over process being continued so as to depress the marginal parts of the top sheet, and of ironing out and smoothing the board to thoroughly adhere the top and bottom sheets to the body.

C. M. SAEGER.

ACTIVITIES OF THE SOCIETY

New Members Received during July

Resident Associate

Carhart, C. C., Sheffield, Iowa, President, Sheffield Brick and Tile Co.

Deppeler, J. H., Jersey City, N. J., Chief Engineer, Thermit Dept., Metal & Thermit Corporation.

Francais, Paul P., Frankfort, Ind., Supt., Ingram-Richardson Mfg. Co.

Hansen, J. E., Mellon Institute, Pittsburgh, Pa.

Hoyler, Fritz W., Perth Amboy, N. J., Works Manager, Roessler & Hasslacher Chemical Co.

Kawai, Kozo, 747 East 36th St., Chicago, Ill.

Kleinfeldt, Henry F., 220 Broadway, New York City, Secretary, Abbé Engineering Co.

Littleton, J. T., Jr., Corning, N. Y., Corning Glass Works.

Offill, Paul M., 901 Oliver Bldg., Pittsburgh, Pa., District Manager, Laclede-Christy Clay Products Co.

Rhodes, George E., 1609 N. Webster St., Kokomo, Ind., Vice-President, and General Manager, Kokomo Sanitary Pottery Co.

Foreign Associate

Brown, Thomas G., St. Laurent, Quebec, Canada, Works Manager, Gurney Foundry Co.

New Members Received during August

Resident Associate

Colburn, Ed. D., 2801 Hereford St., St. Louis, Mo., Superintendent, Blackmer & Post Pipe Company.

Gonder, Lawton G., Zanesville, Ohio, Research Department, American Encaustic Tiling Company.

Gregori, Andrew, 3308 W. Lexington St., Chicago, Ill., Kiln Burner, Midland Terra Cotta Company.

Hammer, John M., Box 555, Pittsburgh, Pa., Managing Editor, "China, Glass and Lamps."

Kingsbury, Percy C., 145 West 45th St., New York City, Chief Engineer, General Ceramics Company.

Knowles, W. V., Peoples Gas Bldg., Chicago, Ill., District Manager and Technical Representative, Titanium Alloy Manufacturing Company and Buckman & Pritchard, Inc.

Rawson, Cummins, Des Moines, Iowa, Iowa Pipe and Tile Company.

Snider, Paul C., 37 Southard Ave., Zanesville, Ohio, Research Department, American Encaustic Tiling Company.

Twells, Robert, Jr., 417 Union St., Schenectady, N. Y., General Electric Company.

Wood, C. P., Stock Exchange Bldg., Philadelphia, Pa., Manager, Philadelphia Office, Lockwood, Greene & Company.

Foreign Associate

Bush, H. T., 59 Yonge St., Toronto, Ont., Canada, President, Universal Silicates, Ltd.

Havas, A. B., 57 Rohrbacher St., Heidelberg, Germany, Consulting Chemist, Roessler & Hasslacher Chemical Company.

Munroe, L. J., 912 Colborne St., London, Ont., Canada, Chief, Enamel Department, McClary Manufacturing Company.

Corporation

"The Glass Worker," Box 555, Pittsburgh, Pa.

Meeting of the St. Louis Section

On Friday, August 6th, the St. Louis Section held a business meeting at Forest Park Highlands with twenty-four members and guests present.

Through the courtesy of Mr. George Thomas, of the Highlands Fire Clay Co., the Section was given the use of the swimming pool and most of those present enjoyed a swim before dinner. Following the business meeting, Mr. F. C. Baker gave a talk on pyrometry which caused an interesting discussion. At the request of Mr. George Thomas the question of the application of rotary filters to filtering washed clays was discussed, the discussion being led by Dr. A. Malinovszky. Mr. A. B. Christopher concluded the program by giving a brief talk on the scumming of fire brick.

Judging by the number of new men attending the meeting and by the interest and enthusiasm shown, the Section should have some very interesting meetings during the coming year.

GAIL R. TRUMAN, *Secretary.*

Ceramic Day at the Chemical Exposition

Friday, September 24th, has been designated as Ceramic Day at the Sixth National Exposition of Chemical Industries at the Grand Central Palace, New York. The program for this day is in charge of the American Ceramic Society. Papers will be given at the afternoon session by representatives of the industrial divisions of the Society. Moving pictures dealing with various ceramic industries will be given in the evening. The meetings will be held in the conference room on the fourth floor.

The Society has been assigned Booth 750 on the fourth floor near the elevator. In this booth the activities of the Society will be demonstrated by charts and by display of the publications of the Society. The Assistant Secretary will be in charge each day to take registrations, to enroll new members, and to explain the work of the Society to visitors. The various ceramic schools will also display illustrations of their work and equipment.

Necrology

Mr. Henry Schmidt died on August 26th following an operation for acute appendicitis.

Mr. Schmidt entered the employ of the Roessler and Hasslacher Chemical Company in May, 1905. After having passed satisfactorily through various positions he was transferred to the ceramic department in June, 1911. By close attention to his work in this department and by pursuing courses in salesmanship and business management, he fitted himself for advancement to the sales department, which he entered on January 1, 1916. He continued in this department up to the time of his death.

Mr. Schmidt was well known to the ceramic industry of this country and was a member of the American Ceramic Society for many years. On account of his pleasing personality, he was liked by all with whom he came in contact; and on account of the integrity of his character, he was highly respected by all with whom he had business dealings. He was more than a salesman; he was a real man who happened to be selling ceramic materials. His sudden death will be greatly lamented by all his friends and acquaintances. Mr. Schmidt leaves a wife and two children.

Report of Summer Meeting, 1920

A total slightly in excess of the century mark established, we believe, a new record for attendance at the Summer Meeting this year, which was held in Chicago, August 16th, 17th and 18th.

The generous contributions toward the entertainment fund by many of the local manufacturers, the splendid coöperation and team work on part of the Local Committee, and the cordial reception tendered by all the plants visited combined to make the meeting highly successful from every standpoint.

The members assembled at the Hotel La Salle at 12.30 P. M., Monday, and proceeded by special elevated train to the plant of The Bach Brick Co., where the use of the Penfield setter and combination fuel oil-steam system of burning proved highly interesting. The same train conveyed the party from here to the plant of the Northwestern Terra Cotta Co. Here the Dressler tunnel kiln, completed and ready for operation, and the new humidity dryers, successfully operating, held the special attention of the party for the remainder of the day.

In the evening, through the generous aid of the local manufacturers, a complimentary dinner was tendered the visiting members at the Hotel La Salle.

The dinner was followed by a short business session, after which "Dean" Gates became master of ceremonies and conducted that office in his usual interesting style. R. H. Minton, President, who had just returned from an extensive trip abroad, gave us a highly interesting talk on industrial and political conditions in Germany. Mr. Minton's talk was followed by one or two other short informal speeches, after which the guests were entertained by two vaudeville stunts. Features of added interest to this event were the presentation of a souvenir terra cotta ash tray to each guest by the American Terra Cotta Co., and of a beautiful ceramic lamp by the Claycraft Shops, to be presented by lot. The Chairman takes this opportunity to announce publicly, and calls on President Minton for confirmation of the fact, that it was by no pre-arranged scheme that the lamp fell to "Dean" Gates, to the great satisfaction of everyone present.

On Tuesday morning, the party visited the plants of the Lindsay Light Co., manufacturers of gas mantles, and were conveyed via taxicabs from there to the Union Station, where they boarded a special car to the plant of the Coonley Manufacturing Co., makers of enameled cooking utensils. Both of these plants proved highly novel and interesting. Leaving here at noon, again by special car, the party was conveyed to the huge plant of the Western Electric Co., where a most excellent complimentary luncheon was served, and cordial reception tendered. The entire afternoon was spent witnessing the various operations employed in the manufacture of equipment used in the telephone and telegraph industry.

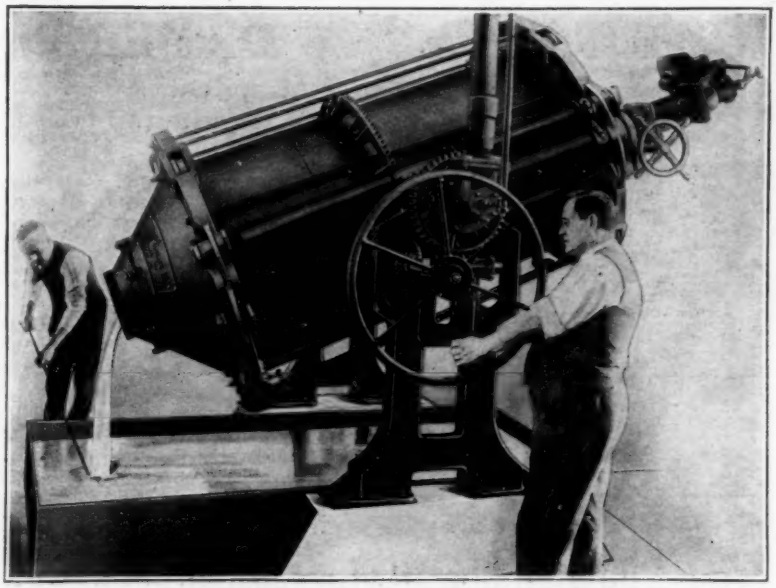
The final day of the meeting started with a pleasant ride on a special train of the North Shore Electric Line, through the beautiful north shore suburbs of Chicago, past Fort Sheridan and Great Lakes Naval Training Station to Waukegan and North Chicago. The first plant visited here was that of the American Steel and Wire Co., where the rolling and drawing of six-inch billets into wire, and the subsequent manufacture of springs, fencing, etc., was watched with great interest.

After leaving this plant the visitors were again tendered a splendid luncheon by the Chicago Hardware Foundry Co., manufacturers of porcelain enameled ware, and found great pleasure in witnessing the various operations employed in this plant.

The return to Chicago was made by special train, several of the members stopping off at Ravinia Park where their attention was divided between the grand opera rendition of "Faust," and a "new" line of stories by Ray Stull.

The sustained interest on part of the visiting members and cheerful adherence to the program as mapped out, made the work of the Local Committee a real pleasure.

F. B. ORTMAN, *Chairman*.



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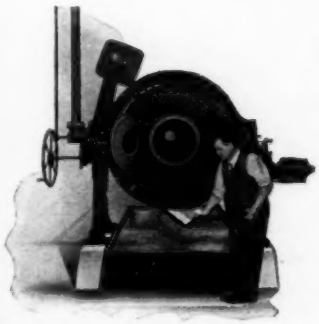

For these reasons: All hand labor, puddling and ravelling is eliminated; overburns cannot occur for the batch is kept in constant motion; oil or gas is used as fuel; uniformity of heat in smelting saves tin oxide and other elements; a turn of the hand wheel tilts furnace and smelted enamel flows slowly into water tank.

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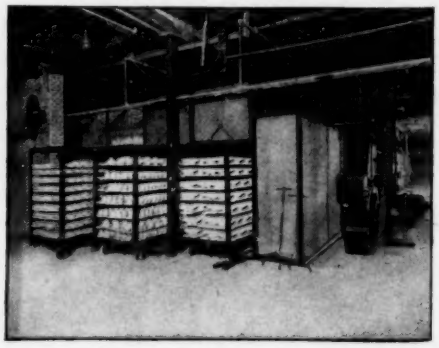

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Note Its Chief Advantages:—

First:—The first cost of this kiln compared with a single tunnel of the same capacity is considerably lower. It requires less brick, one-half of the buck stays, less space, and no side or return track.

Second:—This twin tunnel kiln allows a greater utilization of the fuel than a single tunnel kiln, as the heat from cooling ware is used for water-smoking the incoming ware.

Third:—This kiln allows an absolute and positive control of the firing zone, and in the firing zone a reducing or oxidizing condition can be maintained at will.

Fourth:—The cooling of the ware as well as the water-smoking and pre-heating in this kiln are absolutely automatic. It is impossible to get the receiving end of the tunnel too hot.

Fifth:—This kiln will save about 50% on labor and from 65% to 75% on fuel as compared with periodic kilns. Burning time is cut down by ⅓ to ½. Where saggers are used, they will last twice as long.

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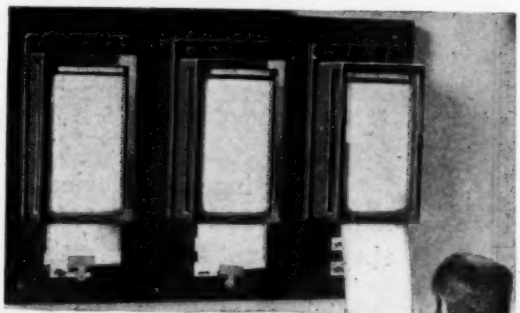

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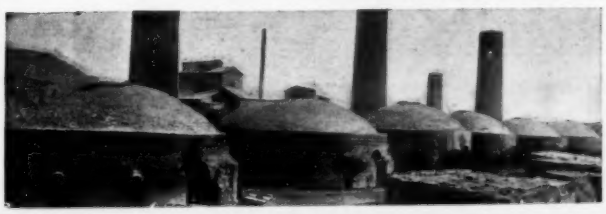

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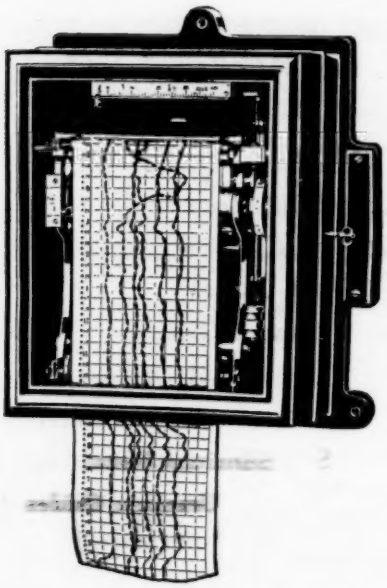

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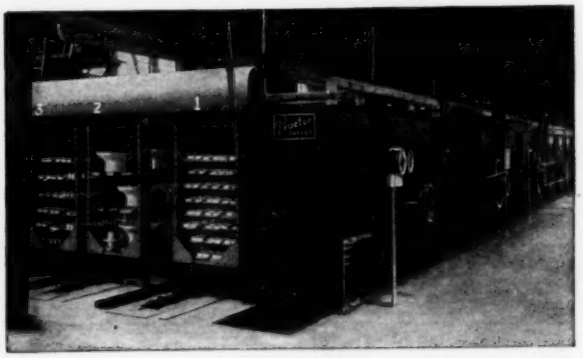

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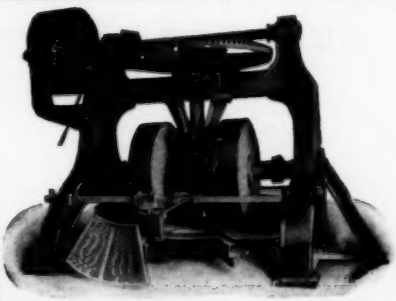

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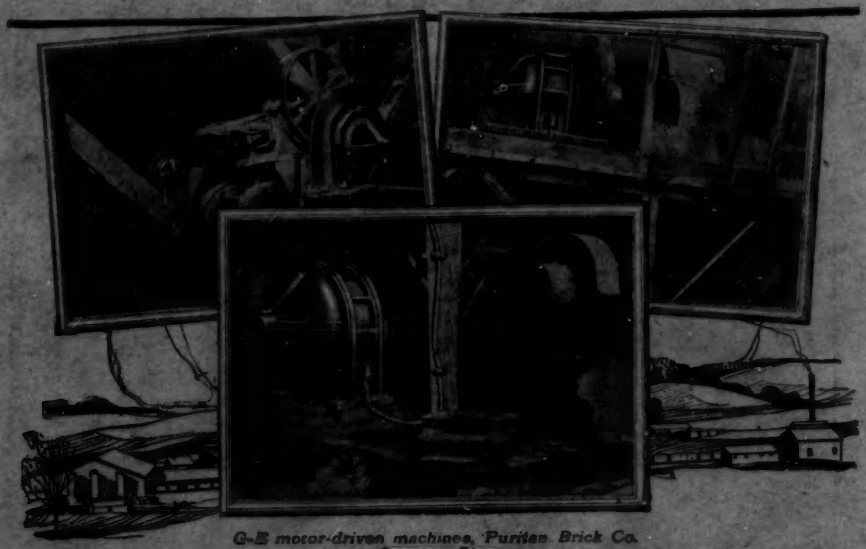

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